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JOURNAL

OF THE

AMERICAN WATER WORKS ASSOCIATION

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OF THE

AMERICAN WATER WORKS ASSOCIATION

The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

VOL. 6 MARCH, 1919 No. 1

COMMENTS

THE ROLL OF HONOR

The American Water Works Association has reason to feel well satisfied with the part its members have taken in the work of winning the Great War. Our Roll of Honor speaks in the language of Patriotism. Our Engineers have constructed the pipe lines and supply works providing water for our armies and for the cantonments, arsenals, and housing projects. Splendid work—valuable beyond estimate—has been done by our Chemists and Bacteriologists in the field, under most difficult and heartbreaking circumstances, and in the camps abroad and at home.

We cannot do enough to honor the men who have sacrificed so much to do their patriotic duty and we look forward to the time when we may meet with them and hear the stories of their achievement. CHARLES R. HENDERSON.

THE TENDENCY TO WANT SOMETHING NEW

An antique or a novelty awakens immediate interest. The nearer an antique approaches the field of archaeology, the wider is its range of interest, probably because it thereby becomes a novelty to an increasingly large circle. The appeal of something new evokes a response in mankind at an early age and manifests itself thereafter in various forms and degrees. More or less acute recollection will doubtless attest the universal popularity of a new girl in a small

town, or in a small section of a large town, the size being limited only by the zone of operations of the girl. With due apologies for mentioning a girl and an antique in the same paragraph, there are certain practical lessons to be drawn from this tendency to want something new.

The symptom sometimes shows itself in decreased interest in keeping a certain apparatus at a maximum pitch because a desired, but perhaps unattainable device, is supposed to be capable of yielding a little better result. The wish for the new article may be the starting point for extended inefficiency, the excuse for which is hidden in the appeal for the wished-for appliance. Visiting operators are liable to return to their own plants with a predominating impression that either they have seen certain machines better than any they possess, or else that they possess better machines than any they have seen.

Perhaps there has not been sufficient emphasis placed on the standards which should govern the determination of whether to purchase or not to purchase a new article. Possibly we should deny ourselves a change until we can conscientiously say that we are already obtaining the utmost out of what we now possess. Such a standard might have interesting results on the operating force as well as on the manager or superintendent.

There must necessarily be various standards of achievement, but high rank belongs to the one who has made the best possible use of the appliances at his disposal, irrespective of the actual returns when compared with those from other appliances. In papers, discussions and publications, there is a tendency to give prominence, perhaps undue prominence, to the new things. A feeling of natural pride dictates this course and a similar feeling of natural reluctance retards the presentation of accomplishments with old and so-called out-of-date equipment. In these days ninety per cent of everything is out-of-date, and an improved appliance is on the market before an original has the paint worn off.

Invention and progress must needs be, but the inclination toward such ends can be over-developed along the mechanical rather than the human side. Labor is to be more costly than ever, but labor-saving efforts may produce large returns if directed towards better utilization of existing equipment through minds influenced to feel satisfied with such equipment, within, of course, reasonable limitations.

CARLETON E. DAVIS.

WATER WORKS CONSTRUCTION AND UNEMPLOYMENT

Six months ago scarcity of materials and labor and restrictions on capital issues made the execution of new works for improving water supplies something which the superintendent viewed with apprehension. Today managers of public works departments of every nature are being urged to carry on construction to the utmost of their ability. The closing down of war industries and the demobilizing of the army have produced the excess of labor which every one knew was coming but for which no real public provision was made. These problems have been under consideration for two years in France and England, where the labor conditions are consequently much better than here. They will remain bad here, in all probability, until men skilled in economics rather than in oratory or journalistic agitation are placed in charge with power to act. Meanwhile the water works superintendent is called upon to help out in a time of national strain by doing things which he knows are worth while in some cases and are unjustified in other cases.

Relief work is not a new thing to some members of this Association. They know how it demoralizes their permanent force if it is conducted improperly and how painfully swollen are the cost records of construction performed with men unaccustomed to the work. Experience shows that when relief work becomes necessary in order to meet the problems of unemployment, the best results are obtained by keeping it apart from other work so far as possible. Some very ridiculous statements are being fed to the papers by publicity bureaus whose employees know nothing about laying pipe, erecting pumping stations or constructing reservoirs. The public is asked to believe that anybody can do these things provided somewhere about the scene there are some blueprints with an engineer to give a technical tone to the picture. The real difficulties of relief work are not even sensed, much less comprehended, and these earnest, ignorant enthusiasts would be shocked to know that in some cases it would be better to give money to unemployed men to keep away from a job rather than use them on work where experience is needed.

Where a superintendent anticipates that he will be called upon to furnish relief work for the unemployed he will usually find it best to make it an independent part of his program, so far as practicable. The last few years have been lean ones and there are many improvements to be made and a great deal of repairs to be undertaken. In most departments appropriations have to be stretched almost to

the breaking point to complete the really essential things with trained gangs. These undertakings have been planned for a long time, as a rule. Some of them are essential and others are very desirable. How shall they be carried out and at the same time take care of citizens out of work? Experience has shown that by forming new gangs, with a few old hands in each but with the greater part of the men green, progress will be slow and costs heavy. Therefore, as a rule, the essential work of the department should not be allowed to become relief work, except under unusual conditions. This essential work should be carried on by the regular water works gangs, built up to the highest possible condition of efficiency, not only because it is desirable to get the work done as quickly as practicable but also because the orderly progress of this work will afford some measure for determining the extent of the disorder of the other work.

Relief work ought to be called relief work and not camouflaged under any other name. It is no reflection on a workman that unemployment has made it necessary for him to sell his labor to a public department, but it is a big reflection on the skill of a superintendent and his foremen to have against his name excessive costs and great delays without an accompanying explanation that they were due to working men not familiar with such labor. The records of relief work in some cities in the past are records of failure unless explained, but when explained they become records of successful accomplishment under unusually trying conditions. It is heartbreaking for a superintendent to find every job lagging because of the inexperienced men on it; his foremen lose heart and finally he gives up trying to accomplish the impossible. But it is a very different thing if his relief work is concentrated where it has the best chance of success, where everybody concerned knows that progress will be slow until the men are taught their duties and the slackers are weeded out, to be handled by the special charity organizations which attend to such cases. The foremen in charge of such work should be specially selected for their tact, knowledge, common sense and firmness, in order that the unaccustomed work may not be made needlessly hard for the men, that shirking shall not go undetected and that loafing shall be dealt with vigorously when a chronic offender is found. Such foremen will make the raw workers respect their job and try to approach the records which the seasoned crews of the department are making.

A. W. Cuddeback.

PUBLICITY IN WATER WASTE PREVENTION WORK

During the war period, the attention of the American public was directed more markedly than ever before to waste, and an appeal made to eliminate, as far as possible, all forms of waste. The waste of water supply was studied by the federal government agencies, as well as by the state and municipal authorities. Appeals were made through notices in the public press and through circularization of water works officials. A brief outline of this subject from the viewpoint of a municipality, with an illustration of what the city of New York has undertaken, may be of interest.

When a municipality undertakes to reduce the waste of water, the usual practice involves the discovery and stoppage of leaks, both in street mains and in plumbing and water fixtures within the buildings, various methods being adopted depending upon the local conditions. Such efforts may or may not be supplemented by a publicity campaign. If such campaign is undertaken, the public press affords the easiest means of communication between the water department and the consumer. Such an avenue of communication is open, however, only when the water situation is such as to give a news value to the articles that may be published. Where there is danger of serious shortage in the water supply if waste be not curtailed, then the press will actively support the water department in its effort to warn the consumers. Where the saving of waste is purely an economic question, the press shows but scant interest. The water department always has available the circularization of its consumers. This can be accomplished either by a special bulletin, or series of bulletins, delivered to the consumers, or by notices attached to the water bills. Both circulars and notices on bills may be effectively employed.

The subject and form of the appeal are both important. The reasons set forth why consumers should reduce waste vary, the more usual reasons being:

a. To avoid a shortage in the supply or a "water famine;"

b. To save labor, fuel and other operating expenses where pumping is necessary;

c. To postpone the construction of new supply and delivery works;

d. To increase pressures through reduction in frictional losses.

By carefully selecting the points which would most strongly appeal to the audience to be addressed, and by presenting these points tersely, the appeal will be made to strike home most effec-

What You Can Do

DON'T let the water run longer than absolutely necessary.

DON'T try to keep milk cold by running water over it. Put it in a pail of cold water

DON'T turn the faucet on and forget it. Turn it off as soon as you are through.

DON'T turn the faucet on so as to give you a larger stream than you need.

DON'T have leaking fixtures. If you hear a continuous noise from the water pipe, water is wasting somewhere. Find the leak if you can, and fix it, or notify your landlord. If he does not fix it at once, notify this department.

DON'T let the water run in the winter time to prevent it from freezing, unless absolutely necessary on very cold nights and then only run a small stream. Protect the water pipes from frost.

IF YOU SEE any water wasting from roof tanks, from hydrants, or from any other cause, notify this department at once.

Remember This!

It costs millions of dollars a year to furnish you with pure water. One of the duties of the department is to prevent waste of water.

IT IS YOUR DUTY to co-operate with this department. When water is wasted, your money is being wasted. DON'T FORGET THAT!

To report water waste, telephone:

Manhattan	-	Worth 4320
Brooklyn	-	Main 3980
Bronx	-	Tremont 3400
Queens	-	Hunterspoint 3500
Richmond	-	Tompkinsville 840

Inspection to Prevent Water Waste

Why

?

Mr. Rentpayer:
Mr. Taxpayer:

READ THIS, THEN SEE THAT EVERY ONE IN YOUR FAMILY READS IT

Issued by

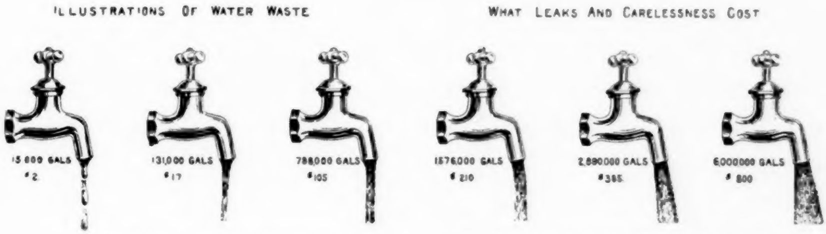
Department of Water Supply Gas and Electricity

THE CITY OF NEW YORK

Nicholas J. Hayes, Commissioner

OUTSIDE PAGES OF WASTE PREVENTION CIRCULAR

Why the Department of Water Supply, Gas and Electricity Has Undertaken a House to House Inspection to STOP WASTE *of* WATER



The figures given under faucet represent the annual flow of water, and its value at meter rates

Do You Know?

HALF A MILLION leaky fixtures are within buildings in New York City.

ONE HUNDRED MILLION gallons of water are wasted every day from those leaky fixtures.

FORTY THOUSAND tons of coal will be used every year to pump this wasted water.

THREE-QUARTERS OF A MILLION dollars will be spent annually to supply this wasted water.

ONE-THIRD of the total supply from the new Catskill system is wasted.

TWO-THIRDS of the total supply from the new Catskill system are not enough for our legitimate needs.

What House to House Inspection Will Do

STOP LEAKS in one hundred and sixty thousand buildings.

SAVE four-fifths of the cost of pumping.

SAVE the coal and labor required to pump wasted water.

INCREASE the water pressure throughout the city.

REDUCE your taxes.

REDUCE the annual deficit of two million dollars in the city's water business.

INSIDE PAGES OF WASTE PREVENTION CIRCULAR

tively. Illustrations are a great aid in attracting the attention of the consumer and securing his consideration of the printed matter presented to him.

Publicity is essentially educational. Its object is to inform the group addressed of facts with which they are either unfamiliar or to which they have failed to give sufficient attention. The water department furnishes an absolutely essential daily need for each person in the community. All members of the community should have reliable information in reference to the water supply and be interested therein.

The actual reduction in consumption of water which is accomplished through a publicity campaign is usually small, except where it is anticipated that a serious shortage of water will result if waste be not checked. In 1910–1911, in the boroughs of Manhattan and The Bronx, such a condition threatened and a publicity campaign, which was vigorously pressed, netted a saving which has been estimated at some 25,000,000 gallons daily. This, however, is the most striking instance in the history of the New York water supply, of a direct reduction in consumption accomplished through publicity work. At the present time the New York City water department is endeavoring to reduce waste of water from a purely economic viewpoint. There is ample water available to meet both reasonable use and waste. To furnish such water it must be pumped at a cost of approximately $25 per million gallons. The method adopted to curtail waste is that of house to house inspection to locate and stop plumbing leaks. It is estimated that there are nearly half a million of such leaks within Greater New York, and that, through the employment on this work of some 100 inspectors daily, all premises can be examined once a year and waste checked that would otherwise amount to some 60,000,000 gallons daily. The publicity side of this work consists in delivering to each family a copy of a circular which is reproduced herewith. A least a million of these circulars are to be distributed by the inspectors as they examine the various premises. It is also proposed to deliver a circular with each water bill. In this way the citizens of New York will be informed of the reason for undertaking a water waste prevention campaign and their co-operation in securing the desired results will be quickened.

W. W. Brush.

MODELS OF STRUCTURES IN THE CATSKILL AQUEDUCT SYSTEM[1]

The Catskill water supply system has a number of complicated structures along its length of 120 miles. It was considered advisable to make models of certain types of these structures to serve not only as an aid to the operating force, which had nothing to do with the design or construction of the Catskill supply, but also as a means of enlightening the public and the engineering profession on some of the latest developments in water-supply engineering.

Moreover, since there occurs at times a reorganization of city departments with a change in administration, together with the normal changes in the personnel engaged on public works, these models will prove of special value to newly appointed heads and their subordinates in charge of operation and maintenance.

A large number of drawings were necessary for each of these complicated structures. In the case of the waterway and drainage Shaft 21 of the city aqueduct tunnel, figure 1, there were 85 contract drawings and 220 working drawings. Many of the features are either submerged or buried in concrete and consequently will be accessible rarely, if ever. To obtain a general conception of the construction and operation from plans involves a great expenditure of time and effort even for an engineer. The models succeed in giving a rapid and comprehensive idea of the construction and functions.

The scale of the models, $\frac{1}{4}$ inch to the foot, precluded the possibility of showing all the details of the drawings. However, all features essential in the construction and operation were brought out. This was accomplished by means of hinged sections or other suitable devices. Loose parts, susceptible of being lost or misplaced, were avoided. No uniform method of construction could be adopted, as each model was of a different type. The accompanying illustrations show a few of the models as built.

[1] Prepared at the request of the Committee on Publications by the Engineering Bureau of the Board of Water Supply, New York City. The models were exhibited at the meeting of the New York Section, October 16, 1918.

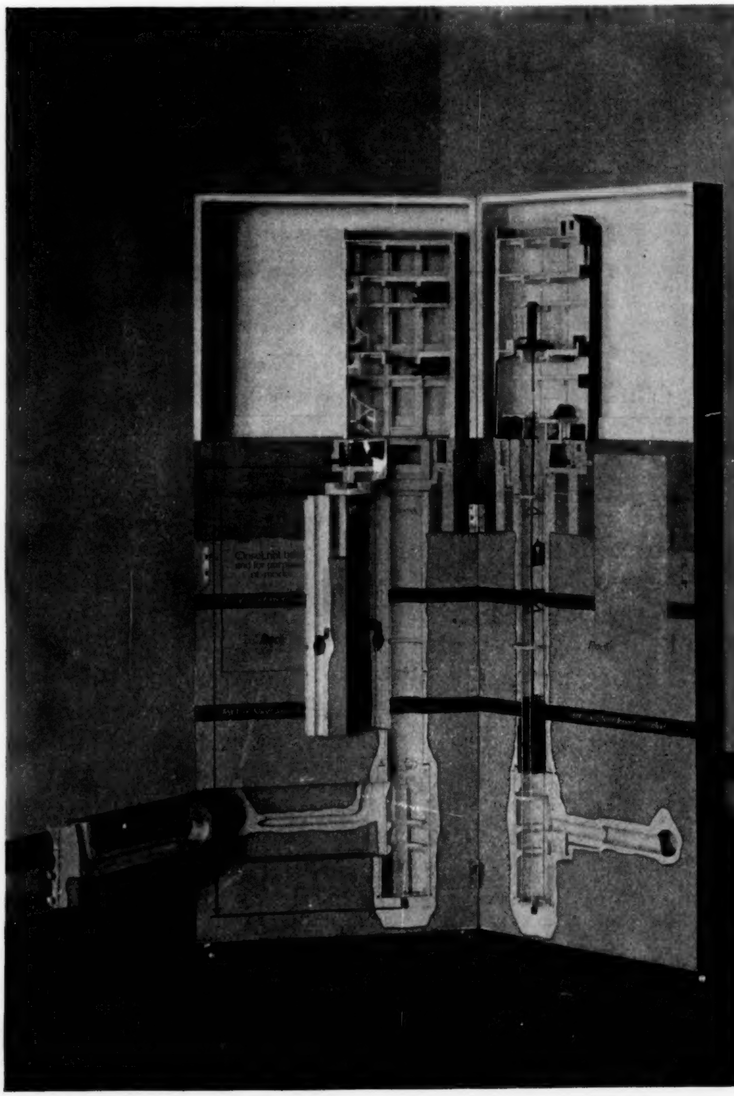


FIG. 1. MODEL OF SHAFT 21, CITY AQUEDUCT TUNNEL

Showing riser pipe, riser valve, valve chamber, superstructure, explanatory tablet and method of unwatering the pressure tunnel. This model has 22 hinged sections.

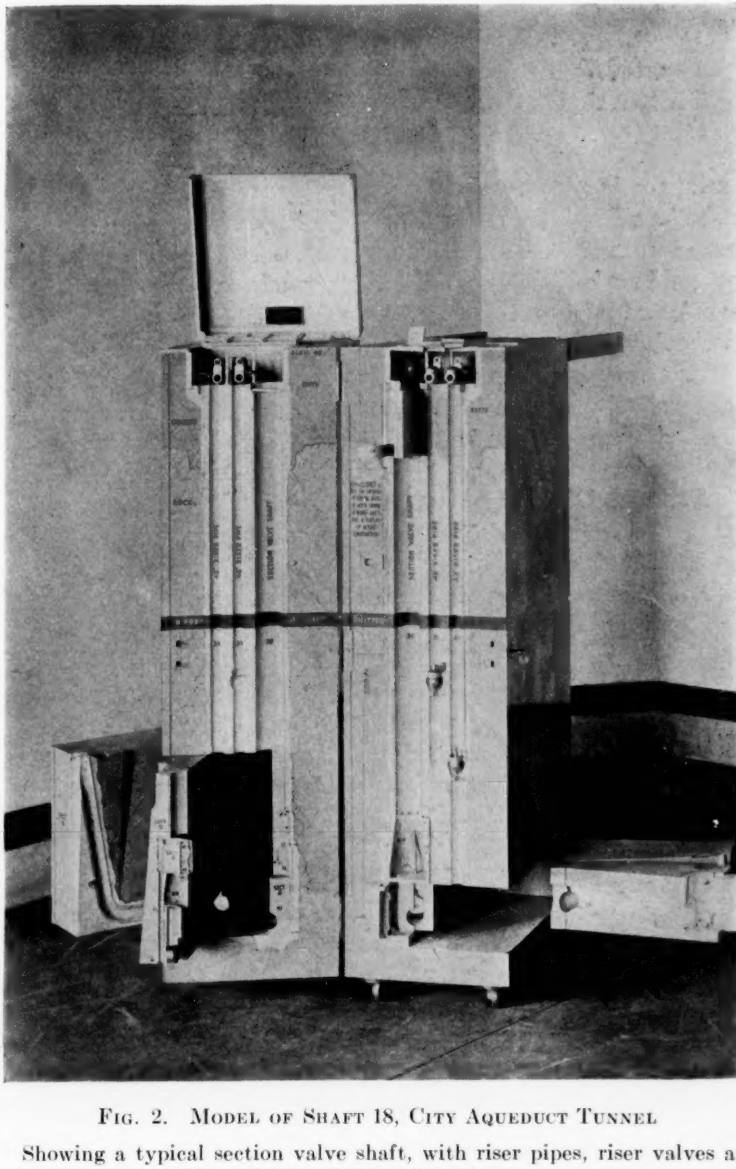


FIG. 2. MODEL OF SHAFT 18, CITY AQUEDUCT TUNNEL

Showing a typical section valve shaft, with riser pipes, riser valves and valve chamber. This model has 20 hinged sections.

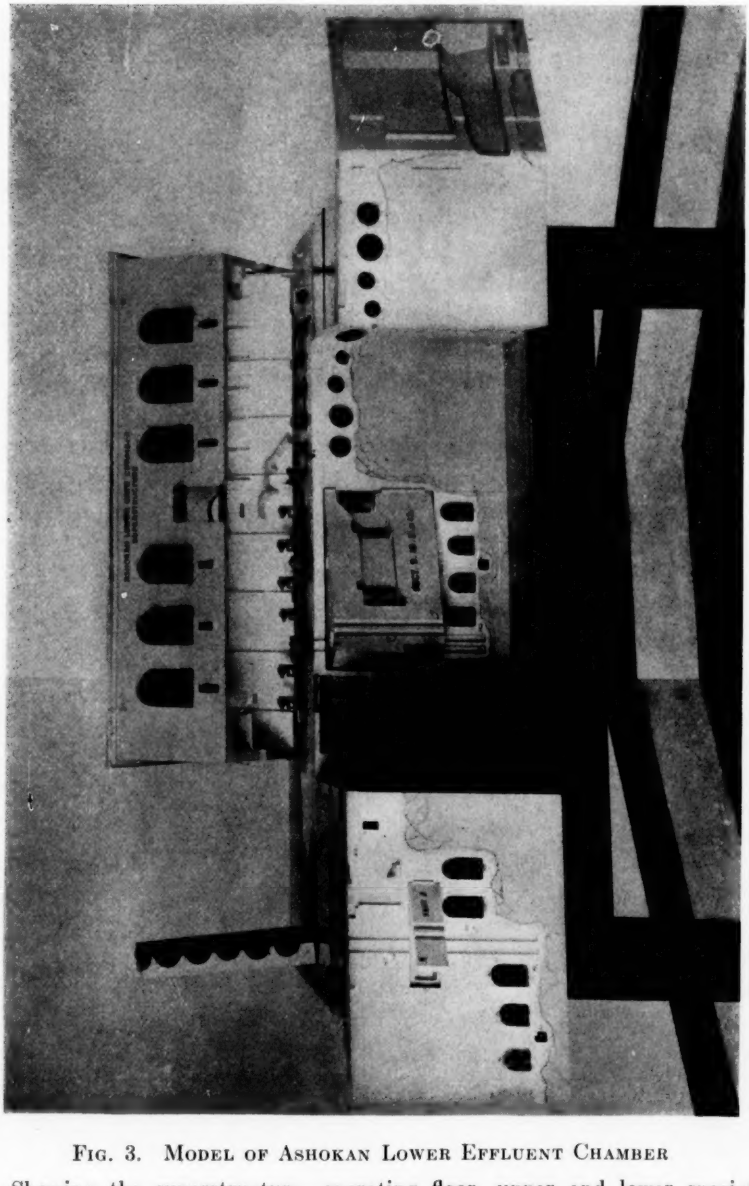


FIG. 3. MODEL OF ASHOKAN LOWER EFFLUENT CHAMBER

Showing the superstructure, operating floor, upper and lower special aqueducts, aerator pipes, passageways to gate wells, etc. There are 19 sections in the main body of the model.

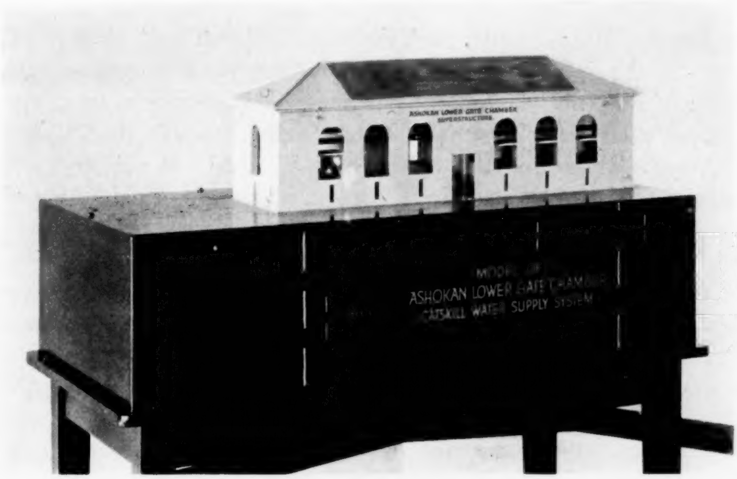


Fig. 4. Model of Ashokan Lower Effluent Chamber

Showing all the sections in place and ready to receive the housing enclosing the upper portion of the model.

Fig. 5. Model of a Section of Cut-and-Cover Aqueduct

Made in connection with a contractor's claim. It has 12 removable parts fitting into the body of the model.

All the models are made of wood, with the more delicate portions of metal. Hard woods, such as walnut, birch and cherry, were used in the interior of the models where rigidity was essential. Clear white pine was used for parts not likely to receive hard usage and mahogany or cherry for the exterior casing. To reduce checking and deformation, thoroughly seasoned wood was selected. The interior of the models received three to four coats of paint, containing a minimum of drier. Different materials were represented by distinctive colors. All features were given reference numbers, explained on an etched plate fastened to the model. When closed, the exterior casing protects the interior from injury. Each model can be locked and is opened by a Board of Water Supply master key.

Owing to the intricacy of the work and the numerous plans, the correlation of which required an intimate knowledge of water-supply engineering, it was realized that even an expert model-maker could not be expected to furnish models which would accomplish the aim desired, to show at a glance the location, shape and functions of inaccessible portions of the work. Assistant Engineer Herman Goldberg was therefore assigned to design and supervise the construction of the models, and it was due to his very painstaking work that such good results were obtained. There were involved the reconstruction of the entire structure in wood and the providing of movable sections which, when opened, disclosed otherwise invisible parts.

The general procedure was as follows: A cabinet-maker built the framework, supports and casing and prepared from dimensions furnished him the wood upon which the assistant engineer drafted the details of the plans. The wood was then turned over to the pattern-makers, who executed the intricate portions. The work was done at a pattern shop and was contracted for on an hourly basis, an allowance being made for the actual cost of materials. Exclusive of superintendence, the models cost from $400 to $750 each.

They are practically the first of their kind, and were made in accordance with the instructions of J. Waldo Smith, Chief Engineer of the Board of Water Supply, who has on many occasions stated his belief in the efficacy of models in working out various engineering problems. At the trial of complicated claims arising out of the construction of engineering works, involving interpretations of specifications, it has been found that models aid the court and jury to visualize the facts involved.

THAWING FROZEN SERVICE PIPES[1]

By A. W. Cuddeback

The communities supplied with water at retail by the companies affiliated with the East Jersey Water Company comprise Paterson, Passaic, Montclair and Clifton, with a total of 32,300 service pipe connections and a population of about 275,000.

There were reported last winter (1917–18) to the companies' offices 1000 frozen service pipes, which was about 3 per cent of the total number. In ordinary winters the companies have, of course, a few frozen service pipes, but not enough to warrant the maintaining of electrical apparatus to provide for their prompt thawing. Ordinary conditions were met by ordinary apparatus. The only equipment maintained for this work has been two or three coils of block tin tubing with force pumps for the purpose of thawing with hot water. This method is fairly effective and satisfactory when only a few cases occur each winter, and where the service pipes are installed with a straight connection to the main so that the tubing can be run from the meter location in the cellar directly through to the main. The freeze-ups during the past winter were reported so fast that they could not be handled with the available apparatus, and it was necessary to provide other more efficient and rapid means.

First a generating apparatus was built. This consisted of a low-voltage generator, which was especially wired at the local electric works, and an automobile engine mounted on a one and one-half ton Sampson truck as shown in figure 1. This apparatus cost, not including the motor truck, about $800. The generator was capable of delivering about 300 amperes at from 20 to 30 volts. The apparatus took six men to handle it, and was attended by a Ford runabout on which were mounted reels carrying the wire to make the necessary connections. An average of anywhere from eight to twelve services per day of eight hours was thawed, and the outfit was worked throughout the busy period with two eight-hour shifts in the twenty-four hours. The generating outfit was moved around

[1] Read before the annual convention at St. Louis, May 16, 1918.

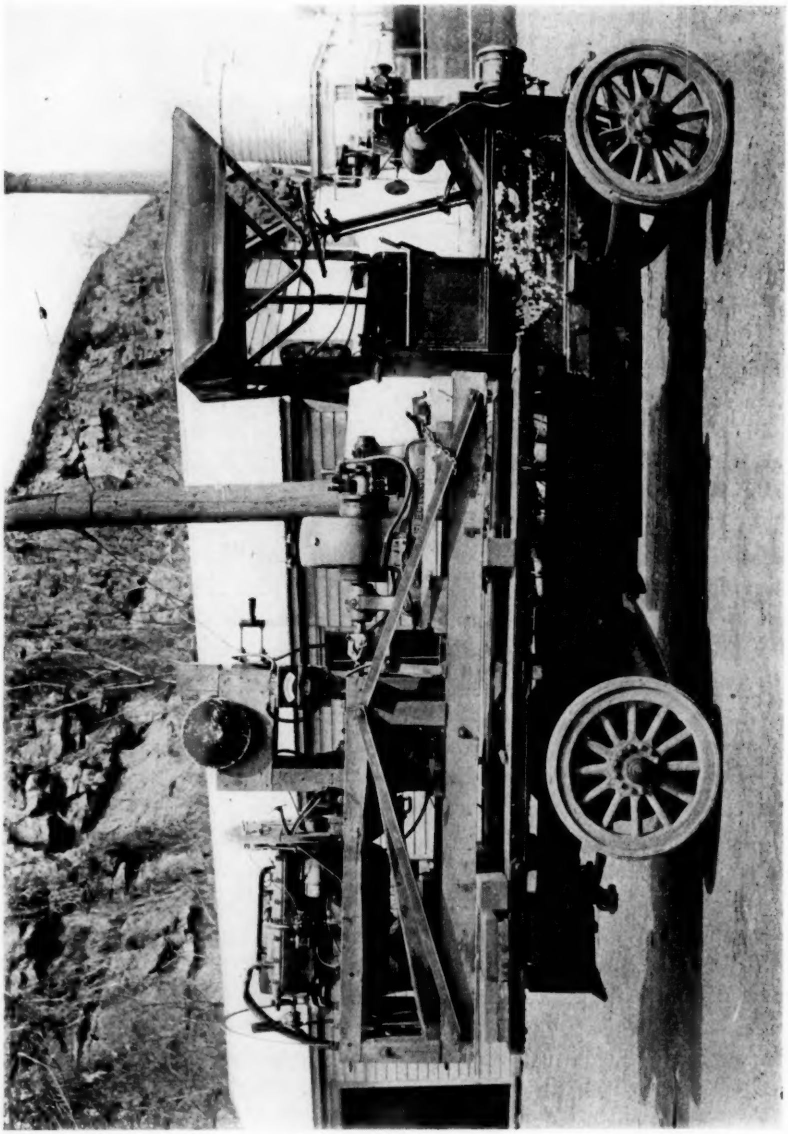


Fig. 1. Generating Set with Gasoline Engine, for Thawing Frozen Service Pipes

to the different communities in which the companies operate, and thus lost considerable time but, generally speaking, was very satisfactory and efficient. It thawed 327 services at an average cost of $8.20 per service.

In addition to this thawing apparatus, one of the local electrical contractors rigged up a storage battery outfit on a Ford automobile. This apparatus was worked for seventeen days and thawed 115 services at a charge of $7.50 each.

The time taken to thaw $\frac{3}{4}$-inch services averaged perhaps thirty to forty minutes. Where services were very old and badly encrusted on the inside, it took from thirty minutes to one and one-half hours. Service pipes directly connected to the main without lead goose-necks could be thawed more quickly than where lead connections were used. The ordinary distribution mains are laid with 4 feet of covering, which perhaps gives a little more than 4 feet covering for the services.

Besides thawing electrically, about 150 service pipes were thawed by tubing and hot water. The average cost of those thawed in this way in Paterson was $11.34 per service; in Passaic $7.63 per service. This included the cost of digging to the main in the street in several instances.

The storage battery equipment consisted of sixty A5 cells, placed in six trays of 10 cells each, and hooked up as shown in figure 2.

Switches A, B, D, and E were three-pole double-throw unfused of 30 size. Switch F was four-pole double-throw unfused, of 60 amperes capacity. Switch C was two-pole double-throw 100-amperes, unfused. The ammeter, A′, and voltmeter, V, were connected as shown in the diagram.

In charging, switches A, B, D and E are thrown down to *c*, and main switch C is thrown to right to CH. This puts all cells in series. With a full battery on the first jobs, C is thrown to the left, to T, and switches A, B, D and E are thrown up to *d*, and the four-pole switch F is in a down position at t'. This connection puts the cells in multiple series (six trays in multiple of 10 series cells each) giving a voltage of about 15 with a large total current flow, but low current rate per unit tray.

When an extremely long service is reached or the battery voltage gets low, switch F is thrown up to position t'', making a series parallel connection of 20 cells series to a unit, and paralleling 3 units, thus adding voltage, but of course increasing the drain on each cell.

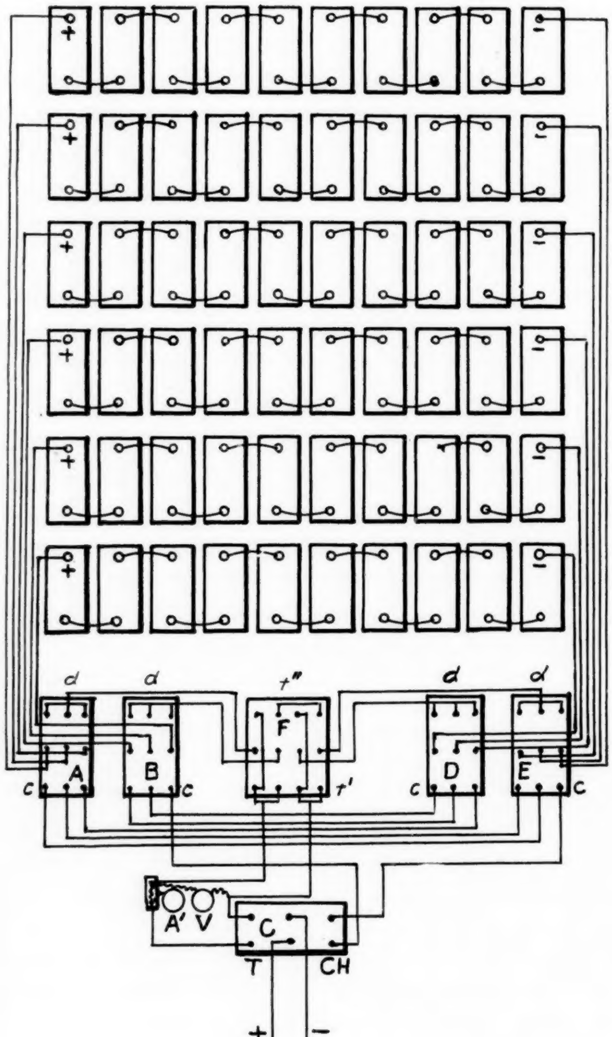


FIG. 2. CONNECTIONS ON STORAGE-BATTERY THAWING OUTFIT

In some cases it was necessary to use the whole 60 cells in series, getting a high voltage in order to break down some obstruction that was evidently in the way of giving a circuit. After obtaining a circuit it was possible to switch back to the first working order and proceed with the work.

Most of the frozen services were $\frac{3}{4}$-inch pipe and it was found that the battery could be thrown directly across the circuit, giving a total flow of about 250 to 325 amperes, the exact amount depending upon the length of the service. The usual custom was to hook on one lead ahead of the water meter, between it and the street, of the frozen service, and the other lead in a similar way to the service next door, or if none was at hand, the nearest hydrant. In a great many cases the services of two adjoining houses were frozen up, and then it was possible to thaw both simultaneously.

It was found that $1\frac{1}{4}$-inch pipe was too much for the equipment, but 1-inch was possible, although it took quite some time. The lengths varied from 60 feet up to 100 feet. These lengths nearly always included the main in the street, varying from 20 to 150 feet. With this equipment, it was not necessary to use a controlling rheostat, as the current was never too high, per cell, in fact very seldom rose over 50 amperes.

These cells were from an electric roadster purchased in 1914 and driven over 8000 miles, but they had been standing idle for the past two years. They were overhauled and put in service at thawing immediately.

It is hard to give the time required to thaw out a $\frac{3}{4}$-inch pipe, for this always depended on the degree of ice in the particular pipe. Some took only four minutes, others one and one-half hours, the latter for 1-inch pipe, but some $\frac{3}{4}$-inch services took as high as one hour. Heat was evident in all $\frac{3}{4}$-inch jobs in about three minutes. The total time after this for complete thawing depended on the condition of the interior of pipe.

A short length of 0000 cable was used, about 50 feet, and about 150 feet of No. 2 duplex, twisted together for leads, thus permitting the outfit to stand in front of the job to be done. The advantages of doing thawing work this way, with a battery equipment, especially for inside house work, are the cleanliness, quickness and entire absence of danger of fire, as compared with a generator equipment.

EXPERIENCE IN THAWING FROZEN WATER SERVICES, HYDRANT BRANCHES AND HYDRANTS AT SYRACUSE, NEW YORK[1]

By Charles A. Windholz

For thawing services, the water department built in 1914, a portable, gasoline-electric, low-voltage, generating outfit. This consists of a four-cylinder, $4\frac{3}{8}$ by 6-inch automobile-type engine, directly connected by a flexible coupling to a 15-kilowatt direct-current generator. The generator is the type used in electric welding and cutting and will operate satisfactorily on any voltage from 10 to 50. It is an interpole, shunt-wound machine. The speed is kept at 1200 r. p. m. by means of a centrifugal governor. Between the engine and generator is mounted a varnished 2-inch oak switchboard on which is placed the main cut-out switch, rheostat, voltmeter, ammeter, and engine controls. Two large wooden reels each containing 250 feet of extra-flexible, rubber-covered, 300,000 c.m. cables are placed at the rear of the machine. The engine and generator, together with radiator, switchboard and reels, are mounted on two 10-inch channels. When desired for service, this unit is placed either on a sled or truck, according to the conditions of the weather, and is easily drawn by one team.

Three men usually accompany this outfit when in service, the man in charge of the machine, the driver and a helper. When the premises to be thawed are reached, enough of the cable is unwound from the reel to reach inside the premises, where it is connected to the service near the stop-and-waste cock. The other cable is connected to a nearby hydrant. Connection is then made between the generator terminals and the cables by inserting a plug on the end of the terminal in the socket to which the inner end of the cable is connected.

The practice in this department is to disconnect the water meter from the service, as it is found that often the current is divided, part going through the service and part through the plumbing in the house and thence back to the hydrant through the lighting company's neutral wire, gas pipes and in other ways.

[1] Read before the annual convention at St. Louis, May 16, 1918.

When properly connected, the engine is started and after attaining full speed, the rheostat is operated until the volt-meter reads approximately 20 volts, when the line switch is closed. As the load comes on, the voltage is increased until the ammeter reads about 500 amperes. The voltage required to maintain this current varies from 20 to 50 volts, according to the length and resistance of the service.

The time required to thaw a service varies from two to fifteen minutes; as a rule, only five minutes is required to start the water running. The small services in Syracuse are all of AAA lead. The department has had no experience in thawing iron services. The time required to make ready, thaw a service, wind up the cable, and get ready to move on is approximately fifteen to twenty minutes, and one outfit can thaw fifteen or more services in a day if they are located not too far apart.

The total weight of the unit is 3500 pounds and its cost was approximately $1500. Although it was built in 1914, on account of the light winters of 1914 and 1915, it was not taken out of storage except for test. In the winter of 1916–1917 about thirty services were thawed. During the past winter (1917–1918), 298 services, three hydrant branches and one 8-inch main were thawed with this outfit. The total cost of labor, teams, fuel and repairs amounted to $921.24, or approximately $3 per service thawed.

Due to the intense cold of the past winter, the ground was frozen to a depth of 4 and 4½ feet. Such a large number of services were frozen that it was impossible to take care of them with this one unit and it was necessary to use three 220–110 volt transformer units to assist in this service. This method of thawing is very satisfactory, but is slower and more expensive than the gasoline-generating unit. For this service, the Lighting Company was paid $1438.03 and the cost of trucks, teams and labor was $417.83, making a total cost of $1855.81, or a cost per service of approximately $8.50. Two 8-inch mains and several hydrant branches and 207 services were thawed with transformer outfits.

During the winter considerable trouble was experienced with hydrants freezing that had not properly drained. For thawing these, a small upright boiler mounted on a light sled was found most convenient. By inserting a steam hose in the nozzle of the hydrant, the ice is quickly thawed and the hydrant placed in operating condition.

FROZEN WATER SERVICES IN THE BOROUGH OF QUEENS[1]

By John T. Metcalf

The question of frozen services and the method of thawing them to restore the supply is of universal interest after the experience of the winter of 1917–1918. In the Borough of Queens, the department of water supply was wholly unprepared to meet the conditions resulting from the extreme cold, and the experience may be interesting to others from that point of view.

In previous winters, a large number of services had frozen, but these can divided into two classes, those which froze every year and, after a month or so, thawed out of their own accord; and those which, by reason of corrosion or other cause which retarded the flow, froze for the first time. Only those in the second class were reported to the department, and investigation usually showed justification for advising the owner that the service was defective and that he should enlist the services of a plumber. If such justification was not shown at the outset, it was possible to show that the main in the street was not affected and, as the trouble was in the service, which belonged to the owner, he was advised to engage a plumber, which disposed of the case. The department was, therefore, relieved of the necessity of maintaining a force or equipment for this work, and it was only in connection with leaks resulting from broken services that it suffered any inconvenience from frozen conditions.

Based on the number of services reported frozen and so recorded, together with the general flood of complaints received in the latter part of January, 1918, which are not recorded, it is estimated that about 500 frozen services were reported during the winter. This figure does not properly represent the total number of services frozen, because a great many cases which were not reported were brought to light through the investigation of those reported.

[1] Presented at the annual convention in St. Louis, May 16, 1918

There were two cases of especial interest. One, reported on April 1, had the service interrupted during Christmas week, and the other, reported April 15, had received no service since December 15, 1917. These cases, when investigated, developed that five and six families, respectively, were affected; that the service froze every winter, and that they were waiting for the service to resume, as it had in previous years. The lines were completely corroded and new lines either have been or are being provided to restore the service.

Following the procedure of previous years, no action was taken by the department, beyond advising the owners to engage the services of a plumber or recommending that the electric company be employed to thaw out the lines. This last suggestion was adopted by a great many owners and, in about a dozen instances, the services promptly froze again, leaving the people without water and with no return for the money expended, as the electric company promptly refused to do the work twice for one fee. This resulted in strenuous complaints, which added to the general chaos of the situation.

About the end of January, the commissioner instructed the engineering bureau to render to the property owners all possible assistance, and the matter was immediately taken up. It was learned that the electric light company was charging $27 per service to thaw out frozen connections, on the basis of a minimum charge of $20 for the use of the equipment and an additional charge for time and current utilized to complete the work. The plan required the owner to advance $27, with the understanding that a rebate would be made if the effort expended did not warrant the full charge. From the information obtained by the author it seems that the full charge was always found to be justified.

The company used three or four gangs on this work, each consisting of a foreman and three linemen. A 1½-ton truck was used to transport the equipment, made up of a transformer, a barrel of water, two electrodes used as a rheostat, and about 1,000 feet of heavy copper wire. The current was obtained from the high tension cables, stepped down through the transformer to a voltage of about 40 and, with about 200 amperes flowing through the connection, the work of thawing was accomplished.

Being satisfied that the price charged was not justified, an attempt was made to hire one outfit and gang from the company on a daily fixed charge for the force and equipment, plus eight cents per kilowatt-hour for the current used. The company, realizing that this

would interfere with its opportunity to secure large profits and maintaining that it had a right to take advantage of the existing conditions, insisted upon a fee of $200 per day for this rental. Realizing that nothing was to be gained from this source, the plan was abandoned.

The services of the electric company were utilized to thaw out about 400 feet of 4 inch main, at an expense of $250, and a 2-inch main about 1000 feet long for $225. Also, a 4-inch main about 150 feet long was thawed out by the department force by excavating at intervals of 50 feet, and thawing between the openings with a steam hose projected into the pipe. This work cost about $75.

During the investigation, a workman with unusual ingenuity was found employed in thawing services. His outfit consisted of an 8-quart cooking pan made to act as a furnace by providing a draught opening at the bottom, in which he burned charcoal. A 1-gallon spout oilcan was used as a boiler and, connected to the spout, with a 3-inch piece of rubber tubing, was a 50-foot length of metallic hose, similar to that used for connecting portable gas ranges. Steam was generated in the oil can boiler and the hose was gradually fed into the service as the ice was thawed. When interviewed, he said he was charging at the rate of $15 per service and was usually successful in thawing a service in half an hour.

The department decided to secure an outfit modeled after this and purchased a 2-gallon boiler, with furnace, and fitted it up with 100 feet of asbestos-packed metallic tubing. With this outfit, an attempt was made to thaw a number of services, but some difficulties were encountered. The lead service offered great resistance to the passage of the metallic hose and it was found practically impossible to insert the hose to a greater length than 25 feet. Even with a lubricant of oil and graphite, it was only possible to insert the hose to a length of 40 feet, and in one instance, when water was injected into the service at this length, the metallic hose was broken in attempting to recover it and about 25 feet was recovered in ribbons. Upon further investigation of the original outfit, it was found that the originator was careful in selecting the services to be thawed, in that no attempt was made to thaw any service which was connected on the opposite side of the street, and only services were selected where the indications led to the assurance that the line was straight from the cellar wall to the connection in the street.

It is evident that this outfit will not serve unless some method can be devised to relieve greatly the friction between the metallic hose and the lead service, and experiments are being made in an attempt to develop this idea. Up to the present time, the only sure method developed by the department for thawing services is with the electric current, and by this method the work can be performed at a cost of $10 to $15 per service.

METERS; OVERSIZING[1]

By William R. Edwards

The controlling principles involved in determining the size and make of meter service should be economy and efficiency. Usually the water department furnishes the meter, and must keep the capital expense as low as possible, consequently the smallest meter that will do the work in any particular case is desirable. Fortunately the second requirement of efficiency is usually obtained by the same selection.

Oversizing is, in the author's opinion, a common fault, and it is better to err in the opposite direction, as in that case attention will be directed to the error by the consumer complaining of poor service, while on the contrary, if the service is oversized in the meter used, a substantial loss may be sustained by the department in under-registration.

Oversizing in meters may be compared to oversizing in automobile tires, in that they will both give longer lives, but the oversize auto tire may also use up more power to move the car and costs more. The oversized meter will not register all the water passing through it and costs more.

The experience of the Passaic Water Company, covering twenty years in time, and the setting, care and handling of some 22,000 meters, is that no matter how much care has been taken, the company has allowed itself to be influenced by the opinion of property owners, mill engineers, architects, etc., with the result that much larger meters were installed than were necessary. That the company's judgment has been swayed is clear by its experience following the installations of the first five or ten years. A careful watch of the performance of individual meters by following their registration, semi-annual tests as to sensitiveness and accuracy, a watch on the difference of water recorded following reduction in size or change in type of meter on a particular service, soon made the fact clear that in many cases meters of too large capacity had been used.

[1] Read before the New York Section, December 20, 1918.

This range covered the use of meters for residential service where ¾-inch and 1-inch sizes had been used when the ⅝-inch was sufficient, to factory or commercial use, where from 1½-inch to 6-inch meters were being used in situations that could better be served by ¾-inch to 2-inch meters.

For the last ten years, during which the business has developed at least 62.8 per cent, and the number of meters in use has increased by 99.9 per cent, it has not been found necessary to buy many meters above ⅝-inch in size. The demands of a growing industrial section for meters of a size larger than this has been met by the withdrawal from service of meters which had previously been set larger than necessary, replacements being made by smaller meters or meters of a different type more suitable for the particular service.

The experience has led to fixing the following general rule covering residential installation: Up to 6 families, a ⅝-inch meter; from 6 to 12 families, a ¾-inch meter; from 12 to 18 families, a 1-inch meter; from 18 to 25 or 30 families, a 1½-inch meter.

For commercial or industrial service, the size and type of meter to be used is determined after all the information available as to the probable quantity to be used and the rate at which it will be drawn has been considered, bearing in mind also in determining the size, the psychology of the water user. Knowing that it is easier to increase than to decrease the size and that such a change leaves a pleased customer, the company is careful not to get an oversize original installation.

The objection of the customer to the placing of a meter of a smaller capacity than his judgment indicates to be necessary is usually satisfactorily met by the assurance that, if found necessary after trial, a larger size will be installed without expense to him.

Where the service demands a large volume at times, with the necessity of taking care of small flows, either of use or leakage, the compound type of meter has been found suitable. This condition frequently arises. For example, on a small town service, where fire protection is of primary importance, but where the ordinary range of draft is greater than the range provided for in a Venturi meter of proper size, a compound meter, which has a current meter for the larger demands with a positive measurement meter for the smaller, is the most suitable type. This condition is also met in many public buildings where flushometers are installed, although for apartment houses and the smaller tenements where the installa-

tion of compound meters of comparatively large size would be necessary to provide for the large flow demanded by flushometers, the use of flushometers is discouraged.

The author agrees with Mr. Caleb M. Saville in the conclusion of his paper read before the New England Water Works Association on November 14, 1918, that it is more effective and economical to install a larger service than has heretofore been the custom than to use a larger meter. Loss of head can be overcome by using the larger service more readily, more economically, and more effectively than by the size and type of meter selected.

Where a larger flow for short intervals is desired than can properly be provided for by the department, giving consideration to accurate registration and first cost of installation, such as filling tubs in a dyehouse, of which the Passaic Water Company has a great many, or providing for the demands of flushometers, the service may be secured by the use of tanks. This shifts the burden of the extra expense of installation from the water department to the customer, but this is justifiable.

The invariable rule of the Passaic Water Company is to use a meter of smaller size than the service to which it is attached. Installations are all made so that a meter can be changed to a different size or type readily and with little expense, in order that changes in use or unforeseen conditions may be easily and readily taken care of.

The determination of the size of the service and the size and type of the meter to be used for any consumer, should be with the water department. The operator of the department does or should know what is required for both proper service to the customer and economical and efficient service for the department.

All meters larger than 2 inches in size are installed so that they can be tested in place without the interruption of the service, and such tests are made twice yearly. All smaller meters are removed for periodical tests, the period being determined by the service which the meter is rendering, or by the requirements of the State Utility Commission, which requires that all meters must be tested after a fixed number of years of service, or after having passed a certain quantity of water, depending on the size.

In conclusion, the author agrees again with Mr. Saville, that more care is needed in the selection of meters for each particular service. The selection should be made by a man experienced in supplying water and with an accurate knowledge of the mechanical qualities

of meters, their limitations and possibilities. Much money can be saved a department, in both installation and operating cost and in securing a full registration of all water delivered, by proper attention to details. Then after the selection as to size and type has been made, one must not be lulled into false security. The water meter is a machine that needs watching. The department has this peculiarity frequently called to its attention by the irate consumer with the high bill, but it should also be warned by the unusually low bill. The price which must be paid for maintaining revenue is eternal vigilance.

DISCUSSION

LEONARD METCALF: The paper invites some questions, such as who bears the expense of repairing the meters, what proportion of the services are metered and what proportion of the water pumped furnishes a revenue.

A. E. HANSEN: It is surprising to hear that a $\frac{5}{8}$-inch meter is sufficient for eight families, and as this size must be dependent for its success on rather high pressures, the author should state the latter.

ALLEN HAZEN: The Spring Valley Water Company in San Francisco has recently become 100 per cent metered. All manufacturing and commercial services have been metered for years and on many of these services the meters were much larger than were necessary. In connection with the complete metering, a new schedule of water rates has been established by the California Railroad Commission which replaces all the old mixed schedules and is universally applied. The new schedule is in the form adopted by the New England Water Works Association. Under it there is a service charge for the service and meter, depending upon the size of the meter, and an additional charge for water. The use of this new schedule tends to bring about a better adjustment of the size of meters to the needs of the service. The company is facilitating this change by sending with each bill, where the quantity of water registered is altogether too small for the size of meter, a polite note to the taker calling attention to the conditions. This letter suggests to him that apparently a meter of a smaller specified size would answer his require-

ments and that, if he wishes, the company will substitute the smaller meter for the larger one without expense to him, and that with this done he will save so much per month on his bill. Sending these letters has promoted cordial relations between the takers and company, and very many takers are accepting the offer, with the result that the number of abnormally large meters is being steadily reduced.

Wm. R. Edwards: In reply to Mr. Metcalf's question, it should be said that the company bears all the expense for repairing meters except when they are caused by frost or hot water. One of the towns supplied has all the services metered, in another 80 per cent are metered and in a third about 70 per cent. It is not practicable to say what percentage of the water pumped yields a revenue, because on the system as a whole there are too many flat rates. In Montclair only 65 per cent of the water is accounted for.

It is not surprising that our experience with $\frac{5}{8}$-inch meters brings out Mr. Hansen's question. We generally use a $\frac{5}{8}$-inch meter where the service supplies six families, but as a matter of fact no complaint has come about the supply furnished through a $\frac{5}{8}$-inch meter to twelve families. The pressure in these cases is 40 to 50 pounds. In Montclair, where the pressure is about 80 pounds, we are supplying without complaint through a $\frac{5}{8}$-inch meter a 12-family apartment house fitted with flushometers.

METER PRACTICES OF THE HACKENSACK WATER COMPANY[1]

By D. W. French

Meter testing. When water meters are first purchased by the Hackensack Water Company, a record of test is required from the manufacturer of the $\frac{1}{2}$-, $\frac{3}{4}$-, 1- and 2-inch sizes as follows: a 10 cubic foot test on full flow, a 10 cubic foot test on a $\frac{1}{2}$-inch stream, and a 0.1 cubic foot test on a $\frac{1}{32}$-inch stream. The complete test for a 3-inch meter is a 10 cubic foot test on full flow, a 10 cubic foot test on $\frac{1}{4}$-inch stream, a 10 cubic foot test on $\frac{1}{8}$-inch stream, and a 0.1 cubic test on $\frac{1}{16}$-inch stream. The complete test for a 4-inch meter is a 100 cubic foot test on full flow, a 100 cubic foot test on 1-inch stream, a 10 cubic foot test on $\frac{1}{4}$-inch stream, and a 10 cubic foot test on $\frac{1}{8}$-inch stream. For a 6-inch meter the tests are a 100 cubic foot test on full flow, a 100 cubic foot test on 1-inch stream, a 10 cubic foot test on $\frac{1}{4}$-inch stream, and a 10 cubic foot test on $\frac{5}{32}$-inch stream. For an 8-inch meter the tests are a 100 cubic foot test on full flow, a 100 cubic foot test on 4-inch stream, a 100 cubic foot test on 2-inch stream, a 100 cubic foot test on 1-inch stream, and a 100 cubic foot test on $\frac{1}{2}$-inch stream.

The records of all tests include the change gears used with each and every meter. Before the $\frac{1}{2}$-, $\frac{3}{4}$- or 1-inch go into service, a separate test is made by the water company, and no meters of these sizes are installed which do not show an inaccuracy of from 1 to 2 per cent against the water company.

The $\frac{1}{2}$-, $\frac{3}{4}$- and 1-inch meters are also subjected to a water pressure test of 350 pounds per square inch by means of a hand pump.

In making tests often required by customers because of high bills, such meters are considered accurate if tests show them to be within 2 per cent either way.

The author feels that he cannot emphasize too strongly the importance of testing carefully all meters which have been frozen. His experience has been in scores of cases that the disc chambers or,

[1] Read before the New York Section, December 20, 1918.

in the rotary piston type of meters, the top head or bottom plate, or possibly both parts, were so badly sprung that merely replacing the bottom casting does not restore accurate registration. It is agreed that because a meter freezes this does not belittle it in any way, although it may cost more to repair some makes than others. Yet there is no good reason why meters cannot be protected from frost and freezing is almost invariably due to lack of consideration or negligence, in either of which cases, the expense of repairs should be borne by the owner of the premises.

Meter setting. All meters used in connection with the Hackensack system are owned and kept in repair by the company, except in cases of misuse or freezing, when a deposit is required to cover the cost of repairs. After this cost is known, the balance is returned to the owner of the premises.

Prior to January 1, 1918, applications for service were made by about 200 plumbers licensed by the water company. After the service main was installed and the building was ready for occupancy, the meter was delivered to the plumber and set by him. Since January 1, 1918, the water company has been setting all meters and the plumbers no longer have anything to do with this part of the work. When the meter is set, a shut-off cock is placed on each side of it and a check valve is also located on the house side of the meter, which acts as a protection to the meter as well as a protection to the property of the owner, should a break occur in the street main.

Only a small percentage of the meters is set in outside meter boxes, and such settings are confined almost entirely to manufacturing plants and private fire lines. Suitable concrete boxes are required for **such** outside settings, and built at the expense of the applicant.

In manufacturing plants, where the use of water is large and often lasts for the full twenty-four hours, the company has found it advantageous, both to the consumer and itself, to install the meters in batteries, which, of course, adds to the expense, but enables examinations, repairs or changes to be made without interruption to the service.

Meter reading. All meters on the system, of which there are about 45,000 in use, are read and billed quarterly, except about 300 in sizes between 1½ and 10 inches, which are read and billed monthly. Meters registering more than 25,000 cubic feet per month are in-

cluded in the monthly survey. All meters in the monthly survey are read on the last day of the month, provided it does not fall on a Sunday or a holiday, in which event readings are made on the following day.

In reading the quarterly meters, the districts are divided into block and working numbers. Each inspector's territory covers about 3500 meters, and he reads, on an average, about 175 meters per day. The quarterly readings begin on the first day of the last month in the quarter, and must be completed not later than the 20th.

Each man starts out with about 200 cards on which readings are entered, and each card, by using both sides, provides for such quarterly readings for a period of four years. These cards are turned in again in the afternoon, together with any and all complaints, such as meters not working, broken glasses, meters leaking, etc., all of which receive attention on the following day. Printed cards are also mailed on the day following the reading to all customers where the meter shows an increased or unusual consumption. The reading cards are then used in making out the quarterly bills.

By repeating this operation each day during the reading period, it is plain that on the day following the last reading day, all defective-reading meters have been changed, that the many and various small complaints have been attended to, that bills have all been made out, and there has been ample time for comparisons, checking, etc., before the end of the month. During recent years the company has not failed in getting into the mail during the last day of the quarter, the entire survey bills, which are then in the hands of its customers on the first day of the following quarter.

Collecting, etc. Promptly after the bills reach the customers, payments begin to come in, and an accurate record and report of collections is made by each district office and tabulated at the main office, showing each morning the sum of money collected in each district and its percentage relation to the survey.

In following any such plan, an excellent opportunity is afforded for comparing the work of the various collectors.

During recent years the records show that about 65 per cent of the total surveys are collected during the first thirty days, and from 26 to 30 per cent during the second thirty day period.

Maintenance. For many years the Hackensack Water Company have been following the practice, initiated in the early nineties, of

removing for test and a general going over, the various sizes of meters after having registered a fixed quantity of water and regardless of the length of time required to reach these quantities. The practical result is that every meter installed on the system comes into the shop at about uniform intervals for a general overhauling. After examination, repair, test and painting, the meter is returned to stock and is ready for another period of use. Following this practice, a very small percentage of meters breaks down, and the author is sure that a higher degree of efficiency is maintained between the intervals of fixed registration.

For more than twenty years the company kept up its original plan of making these changes, as follows: Change all ½-inch meters after registering 100,000 cubic feet; change all ¾-inch meters after registering 250,000 cubic feet; change all 1-inch meters after registering 500,000 cubic feet; change all 2-inch meters after registering 2,000,000 cubic feet. In sizes above ½-inch records were kept of all examinations, including examinations of intermediates, and changes were made when it was deemed necessary.

All such changes are now made under the rules, regulations and recommendations of the Board of Public Utility Commissioners for the State of New Jersey, which are as follows: Change ½-inch meters each 10 years, or after registering 750,000 cubic feet; change ¾-inch meters each 8 years, or after registering 1,000,000 cubic feet; change 1 inch meters each 6 years, or after registering 2,000,000 cubic feet; change all meters larger than 1 inch each four years.

All work in connection with the testing, repair or maintenance of the meters is performed in the water company's shop, which is complete with up-to-date tools and modern testing equipment, and seven or eight men are steadily engaged on this work.

After all is said and done, the real measure of the success of the efforts is the percentage of water actually delivered into the transmission mains that can be accounted for. During recent years the company has been converting into revenue from 71 to 74 per cent of all water pumped at its main pumping station, making no allowance for pump slip, no allowance for loss on mains, no allowance for reservoir seepage, no allowance for water used at fires or flushing of sewers, no allowance for losses due to broken transmission or distributing mains, or losses from service mains leaking between the street main and meter, and no allowance for meter inaccuracies. Such results as have been obtained are due in a large measure to the uniformly careful attention given to the water meters.

DISCUSSION

W. W. Brush: In New York City, the property owner now determines the size of the meter, and generally selects one of the same size as the service pipe. The Department of Water Supply contemplates a greater control of the size of the meter, and where one is found to be so large that it does not register the various flows correctly, a smaller meter will be called for, even if it is smaller than the service pipe. The topics touched on in the paper suggest the desirability of more information on the use of check and safety valves and the possibility of pressure being put on the house plumbing when steam forms in kitchen boilers, and on the setting and repair of meters.

D. W. French: In our system about 87 per cent of the services are metered. The smallest service is $\frac{3}{4}$-inch and a $\frac{1}{2}$-inch meter is used on it. Generally the meter is of the same size as the service, but in some cases it is smaller, for there are service pipes that are found to be needlessly large.

No case has been reported where house plumbing or range boilers were injured because check valves were placed on services and pressure due to steam in the boilers could not be relieved by a back flow through the service pipe. On the other hand there have been many cases where range boilers were protected, by the presence of check valves, from injury when a street main broke. The closing of the check valve prevented the draining of the plumbing systems and the collapse of the boiler. The check valve is preferably placed on the house side of the meter, as it protects the meter from injury by hot water. A safety valve is not of much value, but its cost is so small that the company recommends it as worth its expense, although it is not insisted upon.

The meters are set inside the cellar wall. No particular location is required, other than they shall be 16 to 18 inches above the floor, not exposed to frost, and accessible for reading and changing. When the meter is removed in accordance with the regulations stated in the paper, it is tested to ascertain its inaccuracy. It is then taken apart, thoroughly overhauled, parts badly worn are replaced, and it is reassembled, tested, painted and returned to stock. The quarterly changes from all causes vary from 1.5 to 2 per cent. The meters that are removed in accordance with regula-

tions sometimes show an inaccuracy of only 2 or 3 per cent after being in service a number of years, and sometimes the inaccuracy is 8 or 10 per cent. The cases of large inaccuracy generally occur in meters near dead ends where the mains are liable to contain more sediment than elsewhere.

NEW METER RATES IN THE SAN FRANCISCO DISTRICT

By Allen Hazen

New meter rates have been put in effect by two large water companies in the San Francisco district during the past year. These companies are the Spring Valley Water Company, supplying San Francisco, and the East Bay Water Company, supplying Oakland, Alameda, Berkeley, Richmond and other municipalities. Each system has approximately 65,000 services. The rates were asked for by the companies and the rates and the form of rate schedule were authorized by the California State Railroad Commission after hearings in each case.

Each system is completely metered, the East Bay system for some years. Large takers and commercial takers of the Spring Valley system have been metered for some years, but residences have been metered only recently. The last residences were metered about September 1, 1918, and the new meter rates went into effect at that time. In each case the new schedule supersedes old schedules that were complicated and did not fairly distribute the burden among the different takers.

In the Spring Valley system there were over 50,000 takers at flat rates. In the East Bay system each municipality had its own schedule of rates and the schedules varied among themselves. The new schedule is uniform for the entire system. The Spring Valley rates are arranged to produce the same revenue as the old rates in the aggregate, and it is provided that in the event that through inadvertence or as a result of conditions impossible to estimate accurately, a greater revenue shall be produced, all over-plus over present revenue shall be held at the disposition of the Commission for the benefit of consumers. If there is deficiency the Company loses it.

In the East Bay system, on the other hand, the new rates provide a substantial increase, which was urgently needed to meet the increased cost of service. The new rates are in the general form adopted by the New England Water Works Association; that is to

say, there is a service charge for each meter, graded according to the size of the meter, which is collected whether water is used or not. In addition there is a charge for all water used. In the Spring Valley system the schedule is in the exact form adopted by the New England Water Works Association. For the East Bay system, on the other hand, only two classes are provided, and the point of change from one to the other is not that provided in the New England Water Works Association schedule.

The service charges in the two systems are as follows:

SIZE OF METER	MONTHLY CHARGE	
	East Bay	Spring Valley
inches		
$\frac{5}{8}$	$0.65	$0.50
$\frac{3}{4}$	1.00	1.00
1	1.50	1.50
$1\frac{1}{2}$	2.50	2.50
2	4.50	4.50
3	8.00	8.00
4	12.50	12.50
6	25.00	25.00

The charges for water delivered in the Spring Valley system are:

Between 0 and 3,300 cu. ft. per month..24 cents per 100 cu. ft.
Between 3,300 and 33,300 cu. ft. per month..21 cents per 100 cu. ft.
Above 33,300 cu. ft. per month.............18 cents per 100 cu. ft.

For the East Bay system, the charges for water delivered are:

Between 0 and 5,000 cu. ft. per month....23 cents per 100 cu. ft.
Above 5,000 cu. ft. per month.............19 cents per 100 cu. ft.

The bill is rendered on a form about $12\frac{3}{4}$ inches long and $3\frac{1}{2}$ inches wide. This is in three sections with rouletted lines between them so they can be readily separated. This form is reproduced in figures 1a, 1b and 1c. The schedule of charges is printed on the back of the bill.

Before adopting these rates, there was considerable discussion of the relative advantages of the minimum rate and of the service charge as a means of securing a certain contribution from those takers that draw but little water. Regarding this the Railroad Commission states (Spring Valley opinion):

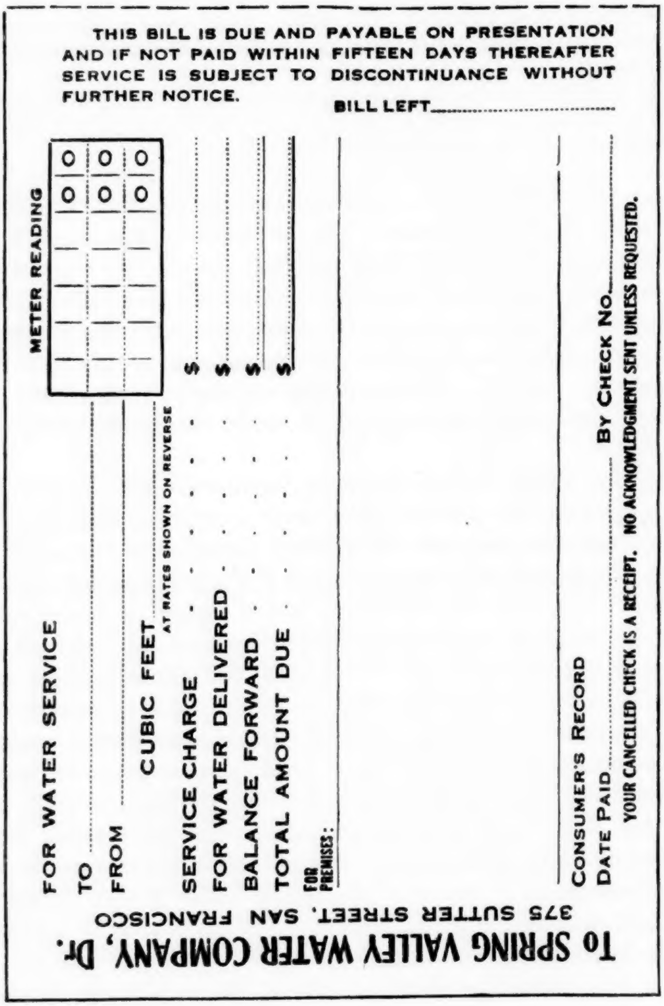
The minimum charge is invariably higher than the service charge, and it involves the payment by each consumer for a fixed amount of water regardless of whether or not he uses it. There is no answer known to us which can be made to the man who complains that under a minimum rate he is compelled to pay the same amount for 100 cubic feet of water as his neighbor pays for 300 or 400 cubic feet of water, depending on the amount fixed for minimum use.

We believe that under the conditions of service we are dealing with herein, the service charge once established and thoroughly understood will be agreed to as the fairest and most equitable method of fixing rates.

The winter of 1917–1918 was the driest in the San Francisco district for at least sixty years. The reservoirs of the water companies were not replenished, and the past season has made very severe demands upon their capacities. The East Bay Water Company has maintained its service by developing temporary ground water supplies wherever there was pervious ground within its range that could be tapped. The supplies so reached may not be permanent, but they have served to carry the company by an emergency.

The Spring Valley Water Company fortunately had considerable amounts of water in storage which have served to maintain the supply during this year, but the gradual depletion of the stock of water on hand could only mean disaster if the consumption kept on increasing. Metering the residences and charging by meter rates has had the effect of reducing the output by a substantial amount. The output is now at the rate of about 37,000,000 gallons per day for the city, which is approximately the rate of 1911, or seven years earlier. In other words, the effect of metering has been to reduce the consumption as much as the natural increase in about seven years, and the increase in consumption during the last two years has been rapid, with numerous war industries that have taken large quantities of water where none was used before. The present per capita consumption of water of the Spring Valley Water Company is about 67 gallons. For the East Bay system it is a little lower, probably between 60 and 65 gallons.

One of the interesting developments of the new meter rates in San Francisco is the gradual substitution of smaller meters whereever the old meter was larger than really necessary for the service. With each bill, where the amount of water is unduly small for the size of meter, goes a polite note from the sales manager of the company, calling the taker's attention to the conditions and suggesting



To SPRING VALLEY WATER COMPANY, Dr.
375 SUTTER STREET, SAN FRANCISCO

FOR WATER SERVICE

TO

FROM

CUBIC FEET

AT RATES SHOWN ON REVERSE

SERVICE CHARGE . . . . $

FOR WATER DELIVERED . . . . . . $

BALANCE FORWARD . . . . $

TOTAL AMOUNT DUE . . . . $

FOR PREMISES:

METER READING

0 0
0 0
0 0

THIS BILL IS DUE AND PAYABLE ON PRESENTATION AND IF NOT PAID WITHIN FIFTEEN DAYS THEREAFTER SERVICE IS SUBJECT TO DISCONTINUANCE WITHOUT FURTHER NOTICE.

BILL LEFT

CONSUMER'S RECORD

DATE PAID BY CHECK NO.

YOUR CANCELLED CHECK IS A RECEIPT. NO ACKNOWLEDGMENT SENT UNLESS REQUESTED.

Fig. 1a. Left-hand Section of Form Used in Collecting Meter Accounts

METER BILL

TO ....

FROM ....

SPRING
VALLEY
WATER
COMPANY
375 Sutter St,
San Francisco

SERVICE ....
....

BAL. FWD. ....

TOTAL ....

CONSUMERS DESIRING RECEIPT PLEASE SEND BOTH BILL AND STUB WITH REMITTANCE. OTHERWISE PLEASE SEND STUB ONLY.

Form 12-84M-Oct. 1918

FIG. 1B. MIDDLE SECTION OF FORM USED IN COLLECTING METER ACCOUNTS

1st. Notice Left ....

Where ....

With Whom ....

By ....

Fin. Not. Left ....

Where ....

With Whom ....

By ....

SPRING
VALLEY
WATER
COMPANY
375 Sutter St.
San Francisco

METER BILL

TO ....

FROM ....

SERVICE ....
....

BAL. FWD. ....

TOTAL ....

METER NO. .... DEPOSIT ....

COMPARED ....

S/O ______ BY ______ WITH ______ AT ______ READS ______

FIG. 1C. RIGHT-HAND SECTION OF FORM USED IN COLLECTING METER ACCOUNTS

that apparently a smaller meter of a size that is suggested would be sufficient, and stating that with the smaller size the saving in the monthly bill would be so much, and stating further that the company is prepared to make the change without cost, if the taker desires it made.

Sending this letter is bringing about a better adjustment in the sizes of meters to the service, which is advantageous to both company and takers, and the takers have appreciated the suggestion. The sales manager states that there have been surprisingly few complaints growing out of the new schedule of rates. A few people have sent checks for the water without the service charge, but these checks have been returned and in practically all cases the situation has been accepted by the takers.

The interesting comment is made that most of the "kickers" are among those who have reduced water bills by the new rates. With very few exceptions those whose bills have been increased have accepted the increase philosophically. They perhaps realized that they have been getting more water than they were paying for and accepted the condition, but the man who has been paying $5 and gets a bill of only $4 under the new rate, considers that he has a confession from the company that he has been overcharged in the past, and he loudly demands to have his bill put down to the point where it really ought to be.

The introduction of the new system of charges by the Spring Valley Water Company was made easier by the distribution to each taker of a pamphlet on the subject of waste prevention and the best methods of paying for water, from which the following extracts are reproduced here:

The necessity for the prevention of waste. To meet the present urgent needs of the city and to prevent a possible future shortage, San Francisco's supply of water must be carefully guarded. The present sources of supply are now drawn to their full capacity, and, unless some of this supply can be saved, additional water must be secured. An additional supply can only be secured by building an additional pipe line to the city and after the pipe line is commenced, it will take three years to complete it. It is impossible to build this pipe line now, because necessary labor cannot be secured, and steel plate and other materials absolutely essential in this construction are required by the United States Government. This means that for the next few years San Francisco must depend upon its present developed supply, and every effort must be made to make that supply sufficient to meet the city's needs. If this is not done, San Francisco will be short of water.

There is one way in which such a disaster can be prevented and there is only one way. It involves the elimination and prevention of waste. Waste of water can be dealt with effectively only by installing water meters. The California Railroad Commission has recognized these facts and has directed this company to install meters. The necessity for installing meters is recognized by every public authority conversant with the situation. This includes the city engineer, the engineers for the Railroad Commission, and the Railroad Commission itself.

Reasons for meters. There are two reasons for installing water meters. First: Their use directly reduces waste. When there is a meter on each service pipe, the party carelessly or wilfully wasting water is made to pay for it. Second: Meters prevent discrimination. When they are used the consumer pays only for what he gets and the company is paid duly for what it supplies.

The old rates commonly called flat rates were unfair. Under them you did not pay for water actually used, but bills were necessarily based on the water which you were supposed to use. This resulted in some consumers paying much more than they should have paid, and in others paying much less. There was no incentive to save and waste necessarily followed.

Most people are careful in the use of water. There are, however, a few whose carelessness or deliberate waste increases enormously the amount of water that must be provided. A leaking toilet may easily waste as much water as would serve twenty families. This water costs money to produce. If those who waste it do not pay for it the burden must be borne by all. This results in the public having a heavier burden to bear and each consumer paying a greater charge. This is particularly true in this city because every gallon of water in the street mains has been pumped from one to four times before it reaches its destination. Pumping requires the use of oil. The company used this year over 100,000 barrels of oil, and the cost of oil has now increased more than 100 per cent.

What the consumer pays for. In supplying water there are three operations:

First: Developing and protecting the water at its source, collecting it in the large storage reservoirs, and pumping and conveying it to the city distributing reservoirs.

Second: Distributing water throughout the city through the main supply lines to the smaller regulating reservoirs, and finally through the distribution lines in each street.

Third: Maintenance and repairs to meters and services, inspection of plumbing and fixtures for the consumers, reading meters, bookkeeping, billing and collecting.

The charge to be made by this company on account of the first two items the Railroad Commission by its ad interim order established. It ranges from 24 cents for each 100 cubic feet for domestic and small commercial consumers to 18 cents for each 100 cubic feet for large industrial consumers. The reason for this distinction is that it costs relatively less to distribute water in large quantities than in small quantities. At the highest rate a barrel of water costs about one cent.

The third item forms the basis for what is known as the "service charge." This has been fixed by the Railroad Commission at 65 cents per month for

ordinary household meters, and increases through intermediate charges to $40 per month for the large 8-inch connections.

The service charge. Each individual consumer pays a specific amount for service rendered to him individually, and the amount which he pays is determined by the size of his service. Unless this is done all these expenses go into the general operating expense account and must be distributed among the consumers without regard to the service to the individual. The service charge is the most equitable arrangement. It is fairer than the "minimum bill" method.

The service charge is not an additional charge and does not mean higher rates. It is simply a different and more equitable way of distributing the cost of service among consumers.

Note that if there is a discontinuance of service, the service charge likewise stops.

No increased revenue to company. The meter rates are ad interim rates. They were put in to prevent waste and to distribute fairly between the consumers the cost of supplying water. They were not put in to increase the company's revenue, and the order of the Commission specifically provides that they shall not do so. The Commission's order says:

"The proposal of the company is fair, to-wit: That the rates now established shall not result in any increased revenue or profit and in the event that through inadvertence or as a result of conditions impossible to estimate accurately, a greater revenue should be produced, all over-plus over present revenue shall be held at the disposition of the Commission for the benefit of consumers."

Effect of meter rates. At least 50 per cent of the company's consumers will pay less than they paid under flat rates. Many consumers will notice no appreciable change in the monthly charges. Others, particularly those whose water is wasted, will pay more than they have paid in the past.

Those who take large quantities of water and who get the wholesale rate will pay more. The old wholesale rate was too low and the Railroad Commission has decided that this class of consumers should bear a larger proportion of the whole cost.

Builders and contractors will pay materially less than under the old schedule. Bills for water service to vessels supplied at open docks will be much less. They were charged too much proportionately under the old rate. Several thousand small stores and shops previously paying the minimum of $1.80 per month will average a saving of between 25 and 50 per cent. By guarding against waste through faulty plumbing and exercising proper supervision of irrigation at least one-half of the residential consumers should reduce their bills.

If your bill is higher than you think it should be look first for waste. If you do not find it see if you are not really using as much water as the bill calls for.

The company maintains a force of experienced plumbing inspectors. This force is at your service and will advise you upon request, free of charge. It is to our advantage, as well as yours, to eliminate waste, and to this end we seek your co-operation.

The rates of both companies are much higher than the average for Eastern cities. This is primarily due to the climatic conditions in California and to the location of the communities upon a wonderful natural harbor but where available sources of water supply are scarce. In a general way, it is estimated that the actual cost of the service is about double what it is on an average for cities on the Atlantic Coast.

The largest company to adopt the New England Water Works Association form of water rates, as far as known, prior to the present instances, was the Hackensack Water Company, supplying Hoboken and other cities just outside of New York.

REPAIRS TO RISERS IN THE SHAFTS OF THE CITY TUNNEL OF THE CATSKILL AQUEDUCT[1]

By J. Waldo Smith

The most obvious means of delivering 500,000,000 gallons daily of Catskill water to the five boroughs of Greater New York was through pipe lines laid just below the street surface. In order to avoid the many difficulties which such a plan would have involved, by reason of interference with traffic and with subsurface structures, and also by reason of the high expense, it was determined to do as much underground work as possible. This decision resulted in the construction of a tunnel 18 miles long, circular in cross-section and with an inside diameter varying from 15 feet at the northern end of the city to 11 feet in Brooklyn. From the terminal shafts in Brooklyn, pipe lines were constructed to the boroughs of Queens and Richmond, the latter on Staten Island.

The construction of tunnels for carrying water under pressure was not new. In order to determine the best location beneath the congested area of the city and through the complicated geological formations which the tunnel in its natural location would penetrate, much exploratory work in the way of borings was necessary. These borings disclosed the character of the rock, and from the results thus obtained it was determined that the tunnel should be located at such depth that nowhere would there be less than 150 feet of rock cover. In general the rock cover is materially greater than 150 feet.

The tunnel is connected with the distribution system through 22 shafts, in each of which there are one or two steel riser pipes 48 or 72 inches in diameter. These pipes are controlled just below the surface of the ground by a substantial valve equipment. The riser pipes placed in the shafts are surrounded with concrete for their entire length, and are thus in a sense integral with the rock through

[1] Read before the New York Section October 16, 1918.

which the shafts and tunnel were driven. The tops of these riser pipes are in the form of tees of solid bronze, and to these tees are bolted 30-inch and 48-inch solid bronze gate valves. The construction at the tops of the riser pipes was the very best and most substantial of which it was possible to conceive, and while it was believed that these bronze gate valves were sufficiently secure to control the supply it was nevertheless thought best to provide one other line of defense by locating a valve from 150 to 200 feet below the surface of the ground and directly attached to the end of the steel riser pipe. These valves, constructed of solid bronze throughout, were of special design and became known as riser valves. They were of two sizes, 48 and 72 inches in diameter, and are operated through a dashpot which has an area equal to one-half that of the waterway in which the valve is placed. The principle of operation is such that if the pressure within this dashpot is at any time reduced below that existing within the riser the valve will immediately and automatically begin to close.

This principle of valve operation has been turned to account by introducing a mechanism which will automatically control the valve operation in case a large break in the distribution system should occur and a dangerous flow of water through the riser pipe result. The operating mechanism for each of these valves is located in the underground chamber at the head of the shaft, and consists of a pair of pitot tubes, one of which looks upstream and the other looks downstream within the shaft riser. The pressures indicated by these tubes are led to two mercury chambers, in one of which there is a large cast-iron float connected through gears to a dial and tripping mechanism. As the pressures indicated by the pitot tubes vary, the position of the float varies and the position of the pointer with respect to the tripping mechanism also varies. As the velocity of flow through the riser pipes increases, the difference in pressure between the two pitot tubes increases, the difference in level between the two mercury chambers increases and the cast-iron float moves, so that finally, when the motion has become great enough, the tripping point of the mechanism is reached. A weight then drops and opens a small automatic valve, and thus immediately the pressure within the dashpot of the riser valve is lowered and the valve itself begins to close. The control mechanism is so designed that the tripping point may be set to accommodate a range of velocities within the riser pipe of from 2 to 15 feet per second.

Control of the rate of closing of the riser valve is had by passing the water discharged from the dashpot, as the valve closes, through a cylinder, from which it escapes through a number of openings or ports. The number of these ports which are open at any time is dependent on the position of the riser valve with respect to its seat. At the beginning of closing, all the ports are open and the valve approaches its seat until only one port or small hole $\frac{1}{32}$ inch in diameter remains open. In this way the speed of closing is held under strict control and the danger of water hammer is eliminated. The entire apparatus is so arranged that the riser valve will close from wide-open to tight-shut in approximately eleven minutes.

Extending from the riser valves to the surface are the riser pipes, which were constructed of sections of riveted steel pipe, the lengths of which varied from 15 to 30 feet. The original design prepared by Designing Engineer Wiggin called for a bolted transverse joint between the sections of steel pipe and recent experience has demonstrated that this should have been used. During construction, however, great difficulty was found in carrying out this plan and a type of hub-and-spigot joint was substituted. This joint was made by riveting an angle-iron seat around the outside of an upstanding end of each section of pipe; the next section of pipe was slightly tapered so that its bottom end was sufficiently large to slip over the upstanding end of the lower section. The upper section then rested on the angle-iron seat and formed an annular space between the ends of the pipe sections. This annular space, about $\frac{1}{2}$ inch in width by 3 inches in depth, was then calked with lead wool. The abutting ends of the steel pipes were reinforced with steel bands, so as to withstand deformation resulting from the calking with lead wool.

As the shafts were sunk, they were first lined with a thin wall of concrete, so as to avoid the necessity of timbering and in order to cut off water which would otherwise have entered from the rock through which the shaft passed. After the tunnel had been completed, the riser valves were built in, and above them the steel riser pipes placed in position, with joints between sections as previously described. The entire space between the concrete of the shaft lining and the riser pipes was then solidly filled with concrete. This concrete surrounding the pipes was usually brought to within about 1 foot below the joint in the riser pipes. After the erection of the steel riser pipes was completed, they were lined inside with 4 inches of concrete as protection against corrosion. It was recog-

nized that, due to the shrinkage of the concrete, slight leakage might occur, and to overcome this grout pipes were placed during the process of placing the concrete and these pipes were subsequently thoroughly grouted. It was also believed that the lead calking would take care of any slight vertical movement which might occur in the riser pipes.

In December, 1917, about at the beginning of cold weather and after the tunnel had been in operation for about a year, it was noticed that there was an inflow of water into the subway at 42d Street. Shortly thereafter water made its appearance in Bryant Park, near the corner of Sixth Avenue and 42d Street. At first it was thought that a break in one of the distribution mains had occurred and the valves at the head of the riser pipes were closed. This did not check the flow, and thereupon the riser valves were shut and the flow stopped. It was thus evident that a break had occurred in the riser pipe somewhere between the riser valves and the valves at the top of the riser pipe.

Preliminary study led to the conclusion that one of the joints in the riser pipes had failed, probably by reason of lifting action by the building up of hydrostatic pressure on the area of some one of the concrete construction joints, and that this pressure had been sufficiently great to result in a lifting force of sufficient magnitude to raise the weight of the superimposed shaft concrete, together with that of the valve chamber and its earth covering, including, of course, the weight of all the valves and fittings within the chamber. The action was analogous to that of a hydraulic ram. A small quantity of leakage water evidently passed through one of the joints in the steel riser pipe and found access to the construction joint in the concrete in its immediate vicinity. This pressure was thereupon spread over a great part of the area of the construction joint, which was substantially equivalent to that of a circle 14 feet in diameter.

With the riser valves closed, the riser pipes were pumped out and examined. This examination confirmed the conclusion which had been reached on consideration of all the conditions as above explained, and it was found that there had been a vertical movement of about $\frac{3}{4}$ inch and that this movement had extended across the entire shaft and had broken joints in both of the riser pipes at a distance of 58 feet below the bottom of the valve chamber.

For the purpose of operating the riser valves there are in this shaft two 3-inch and two $1\frac{1}{2}$-inch bronze pipes. These pipes extend

vertically from the chamber to the riser valves and passed directly across the plane of rupture. It was indeed surprising to find that these pipes had succeeded in withstanding this amount of deformation without rupture. It was evident that they had not broken when it was found possible to close the riser valves immediately after the break had occurred. Later on, when they were exposed to view, it was found that two of them were still intact, although the other two had broken at the threads in each case close to a coupling. The breakage here was probably due to fatigue and did not occur until sometime after the valves had been closed.

The repairs made consisted in placing bronze sleeves about the bronze pipes, removing the lead calking between sections of steel riser pipe and welding these steel riser pipes together by means of the electric arc. In order to gain access to the bronze pipes, which were located outside the risers, it was necessary to cut out of the steel risers pieces large enough so that the removal of the concrete around the pipes could be accomplished. These pieces cut from the riser pipes were also subsequently replaced by welding with the electric arc.

It is believed that the work done has resulted in assuring a greater degree of safety than that called for by the original designs, and that the shaft now is more secure than it was at any time previous. It is even now difficult to conceive just how the break could have occurred, because the concrete with which the shaft was originally lined would hardly have had the strength necessary to withstand the pressure which must have accumulated before the break occurred, but no other reasonable explanation has been advanced.

It was natural that this occurrence at one of the shafts should have directed attention to all of the other shafts where conditions were generally similar. Careful detailed study of these cases was thereupon undertaken, and it was determined to do everything which could be done toward eliminating similar conditions, to the end that the greatest possible degree of security at all of the shafts should be obtained. Pursuant to this policy two things were done. First, a series of borings were put down through the concrete so as to intersect the construction joints in the concrete around the riser pipes. These borings act as vents and will operate to prevent the building up of hydrostatic pressure on the area of any one of these joints. Second, a sufficient number of joints in each shaft were welded in the same manner that the repair at Shaft 17 was made,

so as to afford a very material increase in vertical strength, thus resulting in a balancing between any vertical hydrostatic pressures which might occur and the weight available to resist such hydrostatic pressure.

Tests of samples of the welding, when pulled in the testing machine, have developed over 80 per cent of the vertical strength of the section, and have thus shown a greater strength than that which could have been reasonably attained by any form of welded joint.

It was indeed fortunate that Catskill water became available when it did. The first general delivery was made in January, 1917, at which time Brooklyn was already in bad straits. Last winter, during the extremely cold spell, had it not been for Catskill water, New York City would have been as badly off as Jersey City was, but this is something which the average citizen does not realize, and a condition such as there existed is fully understood only by a water-works man.

DISCUSSION

W. W. Brush: At about 9 p.m. December 11, 1917, the Department of Water Supply of New York received word of a serious water leak that had developed in the subway tunnel at 42d Street. The repair gangs and emergency engineer were called out, and first tested the distribution mains at this location. There are several lines of water mains in and crossing 6th Avenue at 42d Street, and all had to be successively shut down to determine whether any were leaking. At about 2 a.m. it was evident that the leak was on the Catskill system, either from the Catskill shaft or from the tunnel. During the time the source of the leak was being investigated the leakage had increased in volume and amounted to probably some 10,000,000 gallons daily. The water had raised the floor of the subway sufficiently to make it questionable whether the subway trains could continue to operate, a heavy stream was flowing down the subway floor, and water in large volume was coming up along the curb and sidewalk on 6th Avenue, and also within the limits of Bryant Park.

At 2.30 a.m. orders were telephoned to start up the pumping stations on Long Island, where some thirty-two stations that formerly supplied the municipal service in the boroughs of Brooklyn and Queens had been shut down, and placed in reserve. At the same time an order was given to close the emergency riser valves

that were placed in the shaft 100 feet or so below the surface of the rock. It was not then considered likely that the leak was from the shaft, but this was considered a possibility. The department was greatly relieved to get word at 3 a.m. that shutting down the riser valves had stopped the flow, and that it would not be necessary to shut down the main Catskill tunnel. Had it been found necessary to shut down the tunnel, it would have meant cutting off the entire water supply for the boroughs of Brooklyn, Queens and Richmond, and from the lower part of Manhattan. There are two main line valves in the 17½ miles of Catskill tunnel between Hill View reservoir and Brooklyn, one at about 93d Street and Central Park, and the other at 24th Street and 5th Avenue. Both of these must have been closed had the main tunnel ruptured at Bryant Park. To provide against an interruption in the supply of water to Brooklyn and Queens, the department maintains ready for operation nineteen pumping stations connected with the Brooklyn system, and two connected with the Queens system, these stations having a combined capacity of about 150,000,000 gallons daily. In Richmond only two stations are so maintained, having a total capacity of about 8,000,000 gallons daily, as in Richmond there is sufficient stored water in the Silver Lake reservoir to maintain the present demands for a period of about twenty-five days. In Brooklyn and Queens the water stored in the distribution reservoirs would only meet the present demands for a period of less than two days. Some of the city officials have questioned whether the department is warranted in keeping these Brooklyn, Queens and Richmond stations in reserve, ready to operate, and the Board of Estimate and Apportionment that went out of office on December 31, 1917, reduced the number to be maintained in Brooklyn from nineteen to six. This action was reversed by the present Board of Estimate and Apportionment. The cost of maintaining the stations is somewhat less than $200,000 a year. The speaker is certain that no one who had had the experience that he passed through at the time the leak developed at 41st Street and 6th Avenue would question for a moment the advisability of spending this money for insurance, and maintaining the pumping stations connected with the Brooklyn, Queens and Richmond systems ready to operate upon demand.

A few words as to the necessity of the Catskill system to maintain the water supply of New York may be of interest. The unusual severity of the winter of 1917–1918 placed upon virtually all the

water supply systems in the northern part of the country a most unusual burden, due to the very large volume of water drawn to prevent the freezing of pipes and fixtures. In the borough of Brooklyn the consumption on one day reached a maximum of 230,000,000 gallons daily as against a previous average consumption of about 140,000,000 gallons daily. This very high consumption continued for a sufficient period, so that had it not been for the Catskill system, the consumption in the borough must have been reduced by some 30,000,000 gallons daily, with resultant distress and fire danger to property, caused by the general lowering of pressures. In the boroughs of Manhattan and the Bronx, the situation did not indicate quite so clearly the absolute necessity of the Catskill supply, but here the consumption in the months of January and February averaged 425,000,000 gallons daily, whereas the safe supply from the Croton, Bronx and Byram systems is estimated at 350,000,000 gallons daily, these being the systems available prior to the introduction of the Catskill water. The Catskill system has efficiently met all the demands placed upon it, and New York is fortunate in having had at its command during last winter this great source of water supply.

A WATER WASTE SURVEY IN BUFFALO[1]

By Egbert D. Case

Buffalo is an unmetered city. Prior to the spring of 1917 little was done in regard to checking the water waste; on the contrary, the officials rather urged the consumers to use all the water they wanted. With a change of administration in May, 1917, to the commission form of government, the officials started a water waste survey to curtail the waste. At that time the daily consumption amounted to from 165,000,000 to 170,000,000 gallons or over 350 gallons per capita. Today the daily consumption, averaged for the past week, is 130,000,000 gallons or 260 gallons per capita, a saving of 90 gallons per capita per day, without allowing for the natural increase in consumption. At present only 60 per cent of the city has been covered by the survey.

The actual reduction is approximately 53,000,000 gallons daily when corrected for the natural yearly increase. Of this saving, about 10,000,000 is due to underground leakage actually located and stopped, none of which appeared on the surface. The remaining reduction was accomplished by systematic house-to-house inspections, made in connection with pitometer district gaugings.

In organizing the work, the city was laid out into ten sections; each section was divided into six to ten districts. The water was measured by the pitometer in each district, and from the legitimate uses and other conditions in the district, it was determined whether or not a reasonable amount was supplied. The work was started with eight inspectors, and was done under the supervision of one engineer. During the past Summer forty inspectors have been on the job, four gangs in the day and two gangs at night, and four engineers in charge of the work.

The reduction in waste will mean a great deal more to Buffalo than was at first anticipated. During the year ending June, 1918, the city used 61,000 tons of coal. The Fuel Administration has

[1]An informal discussion at a meeting of the New York Section, October 16, 1918.

looked the plant over and limited the amount of coal that it will allow Buffalo to use to 50,000 tons for this year. Buffalo has two pumping stations, each of 150,000,000 gallons capacity. The daily consumption is now well within the range of one station. They have shut down one station for a period of several days and expect soon to shut it down permanently, which will save over 1,000 tons of coal a month.

As to the permanency of the reduction in house waste, it is not possible to make predictions at present. Underground leakage amounting to 10,000,000 gallons a day was due principally to leaking services. There were found 89 corporation cocks leaking badly, about 90 per cent of them being "unfinished supplies." On one block the leakage amounted to 750,000 gallons a day from nine unfinished supplies. Another cause was blown joints; there were found 21 blown joints and 10 broken mains. The broken mains were the biggest source of loss per leak.

Hopper bottom and anti-freezing types of closets are a source of great waste in the poorest sections. The rate has recently been raised on this type of closets from $3 to $10 per year, in an effort to abolish their use. It is hoped that an ordinance will be passed permitting the city to meter a service wherever it finds no other means to control waste.

DISCUSSION

W. W. Brush: The question as to whether taps should be made and services laid to the curb line at the time water mains are installed to supply buildings which will later be erected, and thus prevent subsequent cutting of pavement, is one which is raised from time to time in the majority of communities. Cities which have adopted the policy of placing taps and laying services in advance of building demands, such as Chicago and Buffalo, have experienced very extensive and serious leakage from the unused service pipes. In the speaker's opinion the advantages of such a system are far outweighed by the disadvantages. He was rather surprised at the information given by the author as to the deterioration and ultimate failure of the metal in the service cocks. He had previously supposed that the leakage which would develop from unused services would be outside of the corporation cock. Buffalo's experience with the leakage through the corporation cock

is one which must be due to the character of the water, and it would be interesting to learn whether similar deterioration has been experienced in Buffalo with the meters.

New York City has recently started a house to house inspection to reduce the waste of water. The methods followed are in general those which were successfully adopted in similar inspections made at various times during the past seven or eight years. In the borough of Manhattan alone some 150,000 leaks have been reported. The consumption in the city increased largely over that recorded before the Catskill supply was made available. Catskill water has been generally used to supply the city since the early spring of 1917. The consumption this year has averaged about 70,000,000 gallons daily more than that of a year ago, which is an increase of 15 per cent. During the severe cold of last winter, the increase in consumption averaged over 100,000,000 gallons daily, that for the month of February being 118,000,000 gallons daily. Had it not been for the very large volume of available stored water held in the Kensico reservoir, the abnormal demand of the winter months could not have been met by the Catskill system. This system is now being overdrawn to an extent of about 1,000,000,000 gallons per month. Such overdraft must be stopped, either through the saving of water now wasted, or through the pumping of water, by the utilization of the pumping stations which have been placed in reserve since the Catskill water was made available. In New York it is believed to be possible to save water by house to house inspection at an average cost of less than $5 per million gallons. To pump water at present prices for labor and material would cost about $25 per million gallons, without making any allowance for interest or sinking fund charges. The economy of saving water rather than pumping it, is evident. The author should tell what the financial saving has been in Buffalo.

A. W. Cuddeback: At the East Jersey Water Company's plant at Little Falls, the capacity is being increased about 20 per cent to take care of any possible repetition during the coming winter of the conditions of the winter of 1917–1918. The meters in Paterson are also being increased about 20 per cent. If this is done 85 per cent of the services will be metered; in Passaic 75 per cent are metered and it is hoped to raise this to 100 per cent during the year. The work has been delayed by difficulty in obtaining meters. So far as

Jersey City is concerned, no steps have apparently been taken to increase or conserve its water supply, and that city may have to draw on Newark or Little Falls during the coming winter.

E. D. Case: It is rather difficult to state what has been the financial saving in Buffalo as a result of checking waste, because the actual net saving cannot be determined until the work is completed, in the Spring. The commissioner estimates an annual saving of $130,000 when one pumping station is shut down. The survey will probably cost the city about $100,000 for city labor and engineering services, inclusive.

ECONOMICAL CONSTRUCTION OF A CREEK CROSSING[1]

By John F. Mead

Bayside, in the Borough of Queens, New York City, is supplied by a 12-inch main crossing Alley Creek, a navigable waterway with a channel about 35 feet wide. For a distance of about 100 feet on each side of the channel, the ground is marshy, and the mud is 40 to 50 feet deep, without any solid ground. A 12-inch cast-iron flexible-joint pipe was originally laid across the creek. This line continually leaked. While the department spent considerable money in making repairs, the leaks would start and steadily increase in their volume.

The department then planned to lay a 12-inch main on pile foundations to the sides of the channel and drop under the channel with an 8-inch wrought-iron pipe supported on piles in the channel, 7 feet below low water. The approximate cost of this work was estimated at $5000. Bids were received and, although there was competition, the lowest bid was $7800. The Commissioner and the Chief Engineer of the department decided that this was an exorbitant figure, and decided to do the work by department labor. It was estimated that it could be done within $3000. A gang was organized for this work, consisting of two calkers and six laborers.

It being a very difficult and awkward place to use a pile driver, it was decided to put in the piles by the use of a jet. It is a well known fact that putting piles in sand by the use of a jet is a very economical and efficient method, but it is not generally practiced in mud. It was soon found that there was no trouble in putting the piles down, but there was difficulty in keeping them down, as the water would soften the mud and the piles would rise before the mud settled and held them. This was overcome by using less water and putting the pile down part way with a jet and then tapping it a few feet with a large ram, thereby holding the pile until the mud had a chance to settle back around it and make it firm.

[1] Informal talk at meeting of the New York Section, October 16, 1918.

The next problem was to put piles in the channel and place the supports on them, without the use of a diver. The design for the support of the pipe in the channel consisted of piles driven about 3 feet apart and connected with a wrought-iron U-strap which supported the pipe between the two piles. The department drove the piles to low water, put the U-strap on, making a hinge in this strap, then drove the piles into the mud below the channel by using followers so that the U-strap was to the grade to which the pipe was to be laid. Three sets of these supports were put in the channel. The wrought-iron pipe was made up the proper length with 90 degrees bends at the ends and the uprights connected. It was then pulled across the channel and lowered on the mud on the proper line; then by the use of jets the pipe was washed down until it rested on the supports. This method of doing the work proved very successful, with the result that when the entire job was completed the actual cost to the city was $2500 for work for which the lowest bid was $7800.

In carrying out work it is the little things that very often give considerable trouble. In the construction of pipe lines, especially in the country districts, considerable trouble is often encountered running into pieces of bad and marshy ground. Considerable expense is incurred in the use of sheeting, pumping, building coffer dams, etc. It occurs to the author that an easy method to lay a pipe line across any reasonably short space of muddy or marshy ground, instead of excavating, would be to drive piles with wrought-iron U-strap supports to the proper grade, lay the pipe in proper alignment, and by the use of jets wash it down until it rests on these supports.

A STUDY OF WATER SUPPLY FOR BUDGET PURPOSES

By William W. Brush

Money for carrying on the public works of the city of New York is appropriated by a budget system. The various departments submit detailed estimates of the sums they desire and the reasons for requesting this money at the time, and the appropriations are made, or not made, for these items by the officials in charge of the city's finances. The operation of the water works of the city calls for a very large appropriation and as various alternative sources of supply are available for parts of Greater New York, the engineering recommendations regarding the budget must be based on a variety of factors which have little significance in cities supplied from a single source.

Sources of supply. The city is supplied from five systems, (1) the Catskill; (2) the Croton; (3) the Brooklyn; (4) the Queens; (5) the Richmond.

The Esopus watershed on the Catskill system has an area of 257 square miles and during a succession of very dry years such as occur once or twice in a century it will probably yield 250,000,000 gallons daily. The records from 1907 to 1917 inclusive indicate that it would have been safe to count on 375,000,000 gallons daily. The Ashokan reservoir in which the runoff of this watershed is impounded holds 127,000,000,000 gallons and on June 1, 1918, there was stored in it 113,602,000,000 gallons.

The Catskill aqueduct leading from the Ashokan reservoir to the Kensico reservoir has a capacity at present of 375,000,000 gallons daily. It is a mere coincidence that this capacity is the same quantity as the average runoff of the Esopus watershed in recent years. From the Kensico reservoir to the Hillview reservoir the Catskill aqueduct has a capacity of about 500,000,000 gallons daily.

The Kensico reservoir has a watershed of 22 square miles and during a year of average rainfall this watershed will furnish about 20,000,000 gallons daily. If there is neither increase nor decrease in the amount of water stored in the Kensico reservoir, there is thus

available at the outlet of the reservoir about 395,000,000 gallons daily under average conditions. The reservoir holds 29,200,000,000 gallons and was constructed to provide a reserve supply near the city in case of emergency or when it is necessary to shut down the Catskill aqueduct leading to it from the Ashokan reservoir. It should be full each spring, but the abnormally heavy draft during the winter of 1917–1918, due to protracted, very cold weather, depleted the quantity of stored water somewhat. If the reservoir is to be full on December 31, 1919, about 12,000,000 gallons daily must be added to it, using the condition of the reservoir in the early summer of 1918 as a basis of the estimate, and if this storing of water is done the available supply from the reservoir while this is going on is not over 383,000,000 gallons daily.

The Croton watershed with the existing reservoirs has a safe minimum runoff of 336,000,000 gallons daily and an average runoff of a little more than 400,000,000 gallons daily. The old and new Croton aqueducts have a combined capacity of about 390,000,000 gallons daily. During the early part of the summer of 1918 the draft on this system was about 190,000,000 gallons daily.

The Brooklyn system has a normal yield of about 150,000,000 gallons daily. No water has been drawn from it since early in 1917 but the system can be put in operation again at any time. The Queens system consists of two small plants with a combined yield of 6,000,000 gallons daily. They are not in service now but can be made ready for operation in a short time. The Richmond system comprises six small plants with a combined capacity of about 14,000-000 gallons daily. These are now being held in reserve.

The total capacity of the water works of New York is, therefore, about 955,000,000 gallons daily, and in June, 1918, only 63 per cent of this was being used, namely, 412,000,000 gallons from the Catskill system 5,000,000 gallons from local sources and 190,000,000 gallons from the Croton system.

Consumption. Studies of the consumption during 1917 and 1918 indicate that if no change is made in the pressures and no special measures to check water waste are taken in 1919 the average consumption during the first half of the year in the districts now supplied with Catskill water will be 442,000,000 gallons and during the last half 454,800,000 gallons daily, while in the districts now supplied with Croton water the average draft will be 194,000,000 gallons daily during the first half of the year and 200,200,000

gallons daily after that. The average for the entire city and year is estimated at 645,500,000 gallons daily. If a change is made in the districts supplied with Catskill water, if more measures are taken to check waste or if weather conditions are abnormal, these estimates of the draft during the current year will of course be inaccurate. The amount of water stated is considered a minimum and must be provided if the conditions during the year are as assumed.

In February, 1917, the Department of Water Supply, Gas and Electricity issued a circular stating that as rapidly as possible the new Catskill supply would be introduced in districts of which the boundaries were described. This supply is under considerably higher pressure than the Croton supply then in use, and householders were advised to have their plumbing overhauled to meet the new pressure conditions. In thousands of buildings pumps were then in use to force water to the upper stories, or large tanks at the top of the buildings were allowed to fill slowly during the night, when the normal use of water was small, and serve as reserve sources of supply for the daytime demands. Such service was unsatisfactory and it was considered desirable to furnish Catskill water under sufficient pressure to force it to the top story of the normal type of building in the district where the pressure conditions were worst. This proposed increase in pressure has been carried out only in part. About 29,000,000 gallons daily were furnished during last summer in this district from the Croton supply and about 15,000,000 gallons from the Catskill supply delivered against Croton pressure to raise the Croton's hydraulic gradient in lower Manhattan. The only way to give the desired increase in pressure throughout this district is to pump the Croton supply or replace it by Catskill water. If such a change in pressure is made by either of the possible methods it must be carried out slowly in order that the distribution system as well as the plumbing in private premises may be prepared for it.

From what has been stated it is evident that New York has a large surplus of water available for several years to come. The business problem is whether it is better to furnish more water as the demands increase or to carry out a careful inspection of all premises receiving unmetered water, and what pressure shall be used. These features of the administration of the department were studied and the following conclusions were reached in June, 1918:

A gradually increasing reduction in the waste of water, reaching a maximum of 83,000,000 gallons daily at the end of a year's work may be obtained through employing 126 inspectors and clerks to examine all the unmetered premises supplied with Catskill or pumped Croton water. This work was estimated to cost about $130,000 and if continued for eighteen months $195,000. In this way the depletion of the Kensico reservoir would be ended by the close of 1919 and enough Catskill water would be available to permit its extension into the areas where it had been promised but not delivered or to reduce considerably, the pumping of Croton water. The cost of this waste reduction would be about $5.92 per million gallons up to the close of 1919 and about $4.29 after that date.

Another method of meeting the business problem would be to operate additional pumping stations so as to furnish more water under adequate pressures for the buildings of normal height. About 30,000,000 gallons a day would have to be pumped at the Jerome Avenue Station in the Bronx and about 31,000,000 gallons at the Brooklyn stations. This would cost about $12.23 per million gallons, nearly three times the expense of accomplishing the same purpose by waste prevention measures of a thorough sort.

Another method of meeting the situation would be to replace the Catskill supply furnished under a pressure of about 45 pounds, on an average, with the Croton supply under a pressure of about 26 pounds. This would make it necessary to begin pumping in the houses again, and while it would reduce the consumption of water it would be an unpopular method. The adoption of a thorough system of waste prevention by inspection of unmetered premises was recommended as the best method of meeting the conditions which were anticipated.

The statements made in the preceding portion of this paper give an outline of the water supply conditions of New York in June, 1918, and a knowledge of these conditions is desirable for a study of the economic problem of whether any provision should be made in the 1919 budget for additional pumping, when the need for such provision depends upon the rainfall and runoff in the Catskill watershed during that year being below the average.

Should the budget provide for additional pumping? It has already been stated that the capacity of the Catskill aqueduct from Ashokan reservoir to Kensico reservoir is 375,000,000 gallons daily, and the 1919 budget is based on the continuance of a draft of about this quantity from the watershed. It also provides for a continuance

of a local supply of about 5,000,000 gallons daily from two of the pumping stations on Staten Island, furnishing water to the Borough of Richmond.

During the years 1907 to 1917 inclusive the smallest runoff, corrected for the present reservoir conditions, was 322,000,000 gallons daily and the largest runoff was 427,000,000 gallons daily, the average being 379,000,000 gallons daily. If the reservoir had been full in the spring of 1907 it would have been possible to maintain a draft of 375,000,000 gallons daily from that date to the beginning of 1919 without reducing at any time the quantity of water stored below 34,000,000 gallons this being 25 per cent of the full capacity. It should be noticed, however, that this draft of 375,000,000 gallons is about 125,000,000 gallons daily above the runoff of the Catskill watershed if the latter experiences a series of dry years such as produced minimum runoff conditions on the Croton watershed in 1880. If the city had no other available sources of supply it would be hazardous to exceed materially a draft of 250,000,000 gallons from the Ashokan reservoir, but as there are large substitute supplies it is safe to continue the draft of 375,000,000 gallons so long as the water is available, bearing in mind always that this draft is 50 per cent greater than the safe mimimum supply based on the runoff data of the Croton watershed.

Although many men have studied exhaustively the rainfall records in various parts of this country and Europe, they have been unable to determine any law which will permit a fairly accurate estimate to be made of the amount of future rainfall in a year. In 1903 this section of the country experienced a rainfall of about 9 inches within twenty-four hours. This exceeds the normal rainfall in sixty days. Such a rainfall on the Catskill watershed would be equivalent to 36,000,000,000 gallons runoff, or enough to maintain the rate of draft in the fall of 1918 for a period of three months.

The Catskill water is delivered to the city under a head equivalent to an elevation of 295 feet above sea level, sufficient to permit a gravity delivery to nearly all of Manhattan, all of the Bronx and Brooklyn, and all but a very small part of the remaining two boroughs. Within the areas where the ground is too high for the direct Catskill pressure the consumption is only about 10,000,000 gallons daily. Before the introduction of this supply the city was operating 42 pumping stations at an annual cost of about $1,500,000. This cost would be increased 50 per cent today, on account of the

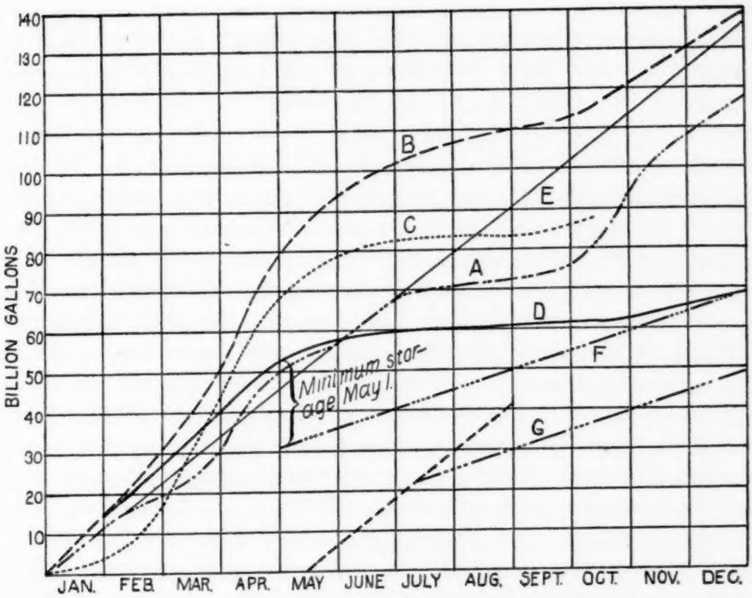


FIG. 1. RUNOFF AND DRAFT CURVES FOR THE CATSKILL (ESOPUS) WATERSHED

A, Runoff from the Catskill (Esopus) watershed for the driest year since 1907, which was 1911.

B, The average runoff from 1907 through 1917.

C, The runoff for 1918.

D, The estimated runoff assuming the low runoff conditions which occurred on the Croton watershed in 1880.

E, Draft line for 375,000,000 gallons daily.

F, Draft line for 156,000,000 gallons daily, which is the difference between a draft of 375,000,000 gallons daily and a possible additional pumpage of 219,-000000 gallons daily.

G, Draft line assuming a storage of 51,000,000,000 gallons on January 1, 1919, and a draft of 375,000,000 gallons daily.

Note: 138,400,000,000 gallons yearly = 379,000,000 gallons daily
136,700,000,000 gallons yearly = 375,000,000 gallons daily
80,000,000,000 gallons yearly = 219,000,000 gallons daily
57,000,000,000 gallons yearly = 156,000,000 gallons daily

increased cost of supplies and labor. There are now five pumping stations regularly operating; thirteen have been partly dismantled and boarded up. The remainder have skeleton crews and are ready for operation in emergencies, in most cases. Assuming that the draft of Catskill water is reduced to the estimated minimum safe supply of 250,000,000 gallons daily, it would be necessary to pump about 125,000,000 gallons daily, which would entail an annual additional expense of about $1,000,000. If any part or the whole of such pumping can be avoided by a draft on the Catskill supply, this should be maintained up to the point where its continuance will jeopardize the sufficiency of the water supply of the future.

Attention is called to figure 1, showing the runoff and draft from the Catskill watershed. It will be seen that the draft line of 375,000,000 gallons daily is within the average runoff curve but the draft line cuts through the 1918 runoff curve in August. If during 1919 there should be a runoff as low as that based on the 1880 Croton runoff, it would be necessary to start full operation of all pumping stations in July in order to retain 20,000,000,000 gallons in the Ashokan reservoir at the close of the year. This quantity is the smallest amount of reserve stored water with which the city should be content. The operation of all the pumping stations would furnish about 219,000,000 gallons daily in excess of the present yield and, on the basis of present prices, would increase the department's expenses above those used in the budget by about $150,000 per month. It seems unnecessary to request a budget appropriation to meet such a contingency, which, if it arises, is better classed as a foreseen but unlikely emergency. The provision of sums to meet these unlikely conditions would swell appropriations above the amount which experience shows to be necessary. It is much better to point out to the city's financial authorities that under exceptional conditions a decided increase over the budget requests may be necessary than to make such requests with the knowledge that probably the increased sums will not be needed.

FURTHER STUDIES ON GENTIAN VIOLET AS A MEANS OF ELIMINATING SPURIOUS PRESUMPTIVE TESTS FOR B. COLI IN WATER*

By Ivan C. Hall and Lillian Jordan Ellefson

The authors' first series of tests showed that the addition of 1–100,000 gentian violet to lactose broth inhibited 94.5 per cent of the spurious presumptive tests for B. coli caused by non-significant gas forming anaerobes (and aerobes) in water. Increasing the concentration to 1–20,000 only raised the efficacy of inhibition, in the case of samples heated to eliminate non-sporulating organisms, to 95 per cent. As to unheated samples, 75 and 81.8 per cent yielded B. coli with gentian violet as against 57.1 and 59.1 per cent without the dye, as shown in the accompanying data abstracted from a former paper.[1] The authors were later definitely able to raise the

	POSITIVE PRESUMPTIVE TESTS	B. COLI	PER CENT
Standard test	21	12	57.1
Gentian violet, 1–100,000	20	15	75.0
Standard test	44	26	59.1
Gentian violet 1–20,000	33	27	81.8

percentage of successful isolations of B. coli through the use of 1–100,000 gentian violet in the plating medium to inhibit aerobic spores, as shown in the following, also taken from the former paper.[1]

	POSITIVE PRESUMPTIVE TESTS	B. COLI ISOLATED	PER CENT
Standard test	22	20	90.9
Gentian violet 1–20,000	21	19	90.5

*The use of gentian violet to eliminate spurious presumptive tests for B. coli in water was discussed by these authors in the *Journal of Bacteriology*, July, 1918. The numerical references in the paper are to the bibliography at the end.

This is fairly satisfactory since B. coli can not be anticipated in every positive presumptive test at this concentration of gentian violet, owing to the fact already shown by the authors that certain few anaerobes are not inhibited even by a concentration of 1–10,000 gentian violet in the media.

The authors had hoped, however, to reach 100 per cent efficiency in isolation of B. coli from positive presumptive tests through increasing the concentration of gentian violet. The present paper points out the realization of this, but also notes the inhibition of the colon bacillus itself at concentrations sufficiently high to inhibit all other gas-forming organisms. In attempting to avoid completely spurious positive presumptive tests, the difficulty of false negative presumptive tests has been encountered. The results have involved the examination of forty samples of water with varying concentrations of gentian violet in the lactose broth presumptive test. These samples were selected by Mr. Frank Bachman of the Bureau of Sanitary Engineering of the California State Board of Health from routine water examinations yielding positive presumptive tests. The authors express their indebtedness for this courtesy. That they have obtained negative results in some cases with samples originally positive is due to delay intervening between the respective tests and consequent loss of gas-forming organisms.

Double strength broth was prepared containing 2 per cent lactose, 2 per cent Difco peptone, and 1 per cent NaCl in meat infusion. The reaction was titrated to 1 per cent normal acidity. This was divided into four lots, to which were added sufficient Grübler's gentian violet to give concentrations of 0, 1–4500,—1, 1500, and 1–500, respectively. The media were tubed in Durham fermentation tubes and sterilized in an Arnold sterilizer by the intermittent method. All other media used were standard, except the litmus lactose plating agar, which contained an addition of 1–100,000 gentian violet for the reasons mentioned in the authors' first paper.

Water samples for the presumptive test were thoroughly shaken. Ten cubic centimeters were then added to each tube so that the final concentrations of ingredients were 1 per cent lactose, 1 per cent peptone, 0.5 per cent NaCl and 0, 1–9000, 1–3000, and 1–1000, respectively, of gentian violet. The tests were incubated at 37°C. and examined daily for gas production up to five days.

Upon the appearance of gas the lactose broth culture was streaked upon one-half the surface of a gentian violet lactose agar plate.

(These plates are best prepared the day before by pouring sterile media into sterile Petri dishes with tile covers to absorb excess moisture. Drying over night at room temperature minimizes spreading, but excessive evaporation after twenty-four hours must be prevented, e.g., by exchanging the tile cover for a sterile glass cover.) The streaked plates were examined on twenty-four and forty-eight hour incubation at 37°C. for acid colonies. If acid colonies appeared, or if, in case none appeared, the colonies resembled B. coli, they were picked to the unused half of the plate. At the end of another twenty-four hours incubation, Gram stains were made and Gram-negative, non-sporulating bacilli confirmed, if possible, as colon bacilli by the usual tests on lactose broth and gelatin at 37°C.

In this procedure the authors have somewhat exceeded the prescription of the Standard Methods for the Examination of Water and Sewage of the American Public Health Association for 1917 in the matter of time of incubation and in the addition of the gelatin test. Also, as in their first series,[1] a second trial was made, if the first failed to yield B. coli, by subculturing from the original presumptive test to a new tube of similar media, and so repeating.

After the examination of 14 samples the method was modified in that the criterion for plating a sample was taken to be either the production of gas or the appearance of growth alone in the presumptive test, as determined by comparing the turbidity of the inoculated tube with an uninoculated tube of the same dilution of dye. Following this technic 26 more samples were examined. Inspection of the original data, however, shows that in but two instances were colon bacilli isolated from presumptive tests showing growth only (which was delayed till the third day), once from a dilution of gentian violet of 1–3000 and once from a dilution of 1–1000.

The first appearance of gas in the presumptive tests of this series is shown in table 1. The summary of the complete data is made as if gas were, as usual, the only criterion for plating, eliminating the two cases above mentioned from table 2.

The data of table 1 support the authors' earlier findings that we are justified in waiting at least four days before calling a presumptive test negative. There is no question that increased concentration of gentian violet in the lactose broth presumptive test markedly delays gas production by the colon bacillus.

It is apparent from table 2 that the formation of gas in seven of the above samples must be attributed to organisms other than

colon bacilli. The relatively large proportion of non-acid plates from which B. coli was isolated is at once disappointing and instructive; it is distinctly higher than in the author's first series.[1] Such plates are frequently to be explained by the co-existence of highly proteolytic bacteria which neutralize the acid produced by colon

TABLE 1

First appearance of gas in presumptive tests in 40 samples of water tested for gas production in varying dilutions of gentian violet lactose broth

DYE	NUMBER OF SAMPLES WITH B. COLI ISOLATED						NUMBER OF SAMPLES WITH B. COLI NOT ISOLATED		
	1 day	2 days	3 days	4 days	5 days	Total	1 day	2 days	Total
0	20	8	2			30	3	4	7
1-9000	8	13	3	1		25			
1-3000		8	5	1		14			
1-1000					1	1			

TABLE 2

Isolation of B. coli from 40 samples of water tested for gas production in varying dilutions of gentian violet lactose broth

PRESUMPTIVE TEST			ACID PLATES	SAMPLES FROM WHICH B. COLI WAS ISOLATED AND IDENTIFIED				
Dye	Gas	Growth only		1st trial	2nd trial	Total	Ratio "a"	Ratio "b"
0	37	1	21	27	3	30	0.818	1.000
1-9000	25	10	12	23	2	25	1.000	0.833
1-3000	14	12	10	15	1	14	1.000	0.466
1-1000	1	7	1	1	0	1	1.000	0.033

$$\text{Ratio a} = \frac{\text{Colon samples at given concentrations of gentian violet}}{\text{Samples showing gas in presumptive test at given concentration of gentian violet}}$$

$$\text{Ratio b} = \frac{\text{Colon samples at given concentration of gentian violet}}{\text{Highest number of colon samples at any concentration of gentian violet of the series}}$$

bacilli; most of these organisms being non-lactolytic, alkali production proceeds from the beginning of their growth on the plate. Unfortunately, they are among the worst spreaders and being Gram-negative are not inhibited by gentian violet as are the Gram-positive sporulating spreaders of the hay bacillus group. From such plates B. proteus, B. pyocyaneus and B. fluorescens are frequently obtained.

Another explanation of plates containing B. coli failing to show acid colonies is that the organisms have exhausted the sugar and begun their attack upon the protein of the media with resultant alkali formation. It is true that reversion from the acid phase to the alkaline phase can be delayed by increasing the lactose content from 1 per cent to 2 per cent, but there need be no trouble from this source alone if the plates are examined on twenty-four hours incubation. For most strains of colon bacilli 1 per cent lactose is in excess of their fermentative capacity unless some means is taken to prevent the accumulation of acid.

The further difficulty of "attenuated" B. coli presents no adequate explanation or solution.

The use of gentian violet in slightly increased concentration in the presumptive test excludes the production of gas by samples from which B. coli can not be isolated, but especially in somewhat greater concentration prevents the production of gas by certain samples in which B. coli is unquestionably present. A dilution of 1–1000 gentian violet almost completely inhibits growth and gas production. In most instances growth without gas formation in the presence of gentian violet has been found to be due to B. proteus and other gelatin liquefying, Gram-negative, non-sporulating microorganisms. These appear to be somewhat more resistant to gentian violet than B. coli.

The upshot of the matter is, therefore, that gentian violet can not be used in as strong a concentration as 1–9000 in the lactose broth presumptive test without danger of inhibiting some colon bacilli; something near this is necessary to inhibit all spurious tests, however. 1–20,000 gentian violet, on the other hand, not only increases the total number of samples from which B. coli can be isolated, but reduces the number of spurious presumptive tests to a minimum.

The condition can perhaps be best displayed graphically by computing the ratios,

$$\text{(a)}\quad \frac{\text{Colon samples at given concentration of gentian violet}}{\text{Samples showing gas in presumptive test at given concentration of gentian violet.}}$$

and

$$\text{(b)}\quad \frac{\text{Colon samples at given concentration of gentian violet}}{\text{Highest number of colon samples at any concentration of gentian violet of the series.}}$$

from the average data of tables 2, 3 and 4 and 5 of the author's first paper[1] and table 2 of the present communication, and plotting these against the logarithm of the dilution as in figure 1. The data so plotted are shown in table 3.

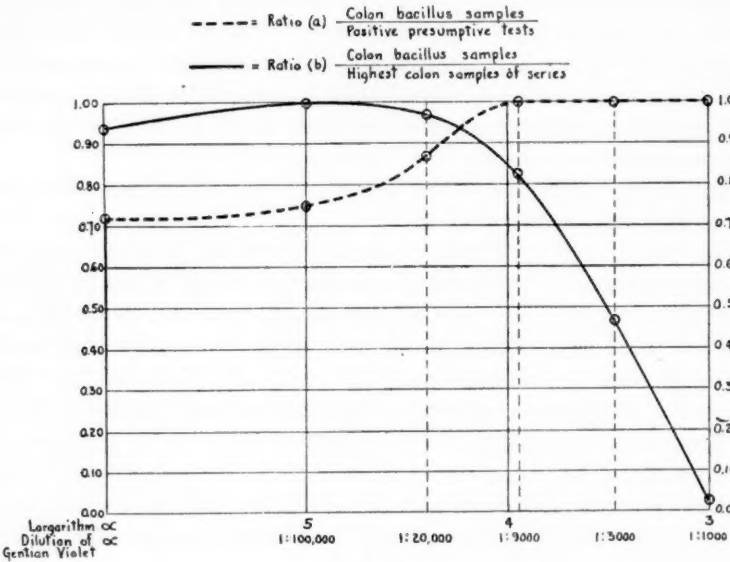


FIG. 1

TABLE 3

DILUTION* OF GENTIAN VIOLET	LOGARITHM OF THE DILUTION	RATIO	
		(a)	(b)
∝	∝	0.725	0.941
100,000	5.00	0.750	1.000
20,000	4.30	0.861	0.975
9,000	3.95	1.000	0.833
3,000	3.48	1.000	0.466
1,000	3.00	1.000	0.033

*Number of cubic centimeters of broth in which 1 gram of gentian violet would be found.

The curves obtained do not coincide in any part. Where they cross between a dilution of 1–20,000 and 1–9000 certainly indicates the maximum concentration which should be used; the optimum lies between 1–20,000 and 1–100,000, probably nearer 1–100,000,

but some spurious presumptive tests must be expected at this concentration. Either of these concentrations can be relied upon to give results superior to the standard test, however.

It is interesting to note that the number of colon bacilli implanted in lactose broth is a factor in the inhibition of gas production by gentian violet; inhibition occurs only when the number of organisms implanted is small. Meat infusion broth with 1 per cent Difco peptone, 0.5 per cent NaCl, 1 per cent lactose and 1–1000 gentian violet was sterilized in Durham fermentation tubes, 9 cubic centimeters each. The control set of media was identical except for the dye. From a twenty-four hour broth culture of B. coli, dilutions in sterile 0.85 per cent NaCl were made, ranging from 1–10 (10^{-1}), 1–100 (10^{-2}), 1–1000 (10^{-3}), etc., to 10^{-20}. One cubic centimeter of each dilution was added to a culture tube containing 9 cc. of the lactose broth. The tubes were incubated at 37°C. and examined for gas daily for three days. From each tube showing gas there was subcultured on plain agar a characteristic coliform bacillus. The results are shown in table 4.

It is most important to record that similar tests with glucose broth failed to show any such inhibition by gentian violet in the same concentration. This point is shown in table 5, which is the record of a carefully controlled experiment using the same culture dilutions for implantation of four sets of media as follows—glucose broth with and without gentian violet, and lactose broth with and without gentian violet. In these tests the media were sterilized in the autoclave before the addition of carbohydrates which were sterilized separately by autoclave in 10 per cent solution in neutral distilled water, and added aseptically in proper proportion to make 1 per cent solutions in the broth. Autoclave sterilization of 10 per cent solution of carbohydrates in neutral distilled water gives no evidence of hydrolysis and avoids the difficulties recently emphasized by Mudge[2] and frequently encountered by every bacteriologist in the sterilization of sugar media. We feel that the above procedure is preferable either to filtration as advocated by Mudge, or to a short sterilization at high temperature as prescribed by the 1917 Standard Methods. The latter especially has been seriously criticized by Hasseltine[3] as inferior to intermittent sterilization in the Arnold sterilizer.

Similar results were obtained repeatedly with meat infusion broth. Of various interpretations which suggest themselves, a

plausible one is that in the presence of glucose the dye is chemically bound so that it becomes less active in the presence of even a small number of organisms. These results might appear to afford a basis for the assumption of carbohydrate-dye compounds analogous to the protein-dye compounds, of which there can be little doubt if we are to accept the conclusions of such comprehensive

TABLE 4

Dependence of inhibition of gas production by B. coli in lactose broth upon the small number of organisms inoculated

DILUTION OF CULTURE	NO GENTIAN VIOLET	GENTIAN VIOLET 1-1000		
	24 hours	24 hours	48 hours	72 hours
10^{-1}	0	0	0	0
10^{-2}	0	0 trace	0	0
10^{-3}	0	0 trace	0	0
10^{-4}	0	—	0	0
10^{-5}	0	—	0	0
10^{-6}	0	—	0 Trace	0
10^{-7}	0	—	0 Trace	0
10^{-8}	0	—	0 Trace	0
10^{-9}	0	—	0	0
10^{-10}	0	—	0	0
10^{-19}	0	—	—	0
10^{-12}	0	—	—	0
10^{-13}	0	—	—	0
10^{-14}	0	—	—	0
10^{-15}	0	—	—	0
10^{-16}	0	—	—	0
10^{-17}	0	—	—	0
10^{-18}	0	—	—	0
10^{-19}	0	—	—	0
10^{-20}	0	—	—	—*

*Positive in five days. 0 indicates gas production.

The essentials of the above data were confirmed by repetition of the experiment.

reviews and investigations as those of Mathews,[4] Heidenhain,[5] Mann[6] and Robertson,[7] on this subject. A single failure to repeat the results of table 5 with meat extract broth in which no growth of B. coli could be obtained in either plain, glucose, or lactose broth with 1–1000 gentian violet may be taken to indicate that protein enters into the reaction, possibly in the form of glucosamin.

We may, therefore speculate somewhat as follows: lactose, having no such ability as glucose of combining with gentian violet, leaves the dye free to act upon the bacteria in such a way as to prevent their multiplication. There is no evidence to show that inhibition of gas formation occurs without inhibition of growth, otherwise we might conclude that the sugar is rendered unavailable. In either case their is no noticeable precipitate in the medium such as is frequently the case in dye protein compounds.

The introduction of large numbers of B. coli appears to overrule the inhibitive action of gentian violet in a dilution of 1–1000, and a *delayed* growth and gas production may occur with relatively small

TABLE 5

Failure of inhibition of gas production by B. coli in glucose broth

DILUTION OF CULTURE	GLUCOSE BROTH		LACTOSE BROTH			
	No gentian violet 24 hours	Gentian violet 1-1000 24 hours	No gentian violet 24 hours	Gentian violet 1-1000		
				24 hours	48 hours	72 hours
10^{-1}	0	0	0	0	0	0
10^{-2}	0	0	0	0	0	0
10^{-3}	0	0	0	Trace	0	0
10^{-4}	0	0	0	Trace	0	0
10^{-5}	0	0	0	—	Trace	0
10^{-6}	0	0	0	—	Trace	Trace
10^{-7}	0	0	0	—	Trace	Trace
10^{-8}	0	0	0	—	Trace	Trace
10^{-9}	0	0	0	—	—	Trace
10^{-10}	0	0	0	—	—	—
10^{-11}	—	—	0	—	—	—
10^{-12}	—	—	—	—	—	—

0 indicates gas production.

numbers of introduced bacteria. These phenomena might be interpreted as due either to acclimation of the bacteria to the dye, for which Shiga[8], and Fitzgerald and Mackintosh[9], have separately presented evidence in the case of other organisms, or to reduction of germicidal power by adsorption between certain individual bacteria and the dye, leaving certain other individuals free to multiply.

Analogous to the action of lactose is that of agar, which belongs to the group of colloidal polysaccharids, in the presence of which

both Gram-positive anaerobes, such as B. oedematis, B. botulinus, and B. welchii, and Gram-negative aerobes, such as B. coli, require more gentian violet for their inhibition.

SUMMARY

This paper extends the observation previously made showing the practical utility of a high dilution of gentian violet for eliminating spurious presumptive tests for B. coli in the lactose broth fermentation test of polluted water. It is shown that if the concentration of dye be sufficiently increased every positive presumptive test can be relied upon to yield B. coli, but the total number of positive tests is likely to be reduced. A low concentration of dye, however, yields a higher proportion of successful isolations of B. coli than the standard method, yet a certain low percentage of spurious presumptive tests must be anticipated.

Glucose broth containing a high concentration of gentian violet is less inhibitive for B. coli than lactose broth, which leads to certain theoretical considerations involving the possibility of dye carbohydrate compounds analogous to dye protein compounds.

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SOME TESTS OF ELECTRICALLY OPERATED DEEP WELL PUMPS[1]

By P. S. Biegler and I. W. Fisk

About a year ago the writers presented a paper before the Illinois Section of the American Water Works Association, setting forth the results of tests of pumping units at the plant of the Champaign-Urbana Water Company, including a study of the operation of a cam-type, motor-driven pump at various speeds above and below normal. In the present paper are given the results of tests showing the performance of a crank-type, motor-operated pump of recent design for a wide range of speeds and for a considerable range of head for each speed. The pump is of the belt-driven double-action deep-well type; having a bore of $6\frac{1}{4}$ inches, a stroke of 18 inches and a speed of approximately 26 revolutions per minute.

For the measurement of discharge, a calibrated orifice bucket was used and extreme care was exercised in getting accurate results by having one man watch the gage constantly, averaging the readings during each stage of the tests. The depth of water in the well was determined by means of an electrical contact device sensitive to a variation of water level of 1 inch, and a polyphase rotating standard watthour-meter made possible very accurate readings of power intake of the driving motor in spite of the fluctuating nature of the load. All of this apparatus was fully described in the paper referred to above, published in the Journal in 1917.

In order to investigate the performance of the pumping unit at various heads, a valve was inserted in the discharge pipe of the pump, and, by restricting the opening, it was possible to increase the effective head against which the pump was operating, for each size of pulley, i.e., for each pump speed.

In table 1 are shown the complete experimental data and a few words of explanation should make clear the method of arriving at

[1] Read before the Illinois Section at Urbana, April 16, 1918. Certain tables and illustrations in the original paper giving details of the tests have not been reproduced.

TABLE 1

Test of an electrically driven deep well pump

CURRENT SUPPLIED		PUMP		TOTAL HEAD	DISCHARGE, GALS. PER MINUTE			OUTPUT	EFFICIENCIES		
		Pulley	Rev. per minute		Theoretical	Actual	Slip		Motor	Pump	Over-all
kw.	*h.p.*	*inches*		*feet*				*h.p.*	*p.c.*	*p.c.*	*p.c.*
3.725	4.92	4	19.65	148.3	94.3	82.5	11.8	3.09	82.8	75.7	62.8
3.815	5.11	4	19.65	148.3	94.3	82.5	11.8	3.09	82.9	73.0	60.5
2.765	5.045	4	19.65	148.3	94.3	82.5	11.8	3.09	82.8	73.9	61.4
4 31	5.78	4	19.58	177.4	94.0	82.0	12.0	3 67	84 0	75 5	63.5
4.317	5.782	4	19.52	177.4	93.7	83.0	10.7	3.72	84.0	76.5	64.4
4.292	5.755	4	19.56	177.4	93.9	82.0	11.9	3.67	84.0	76.0	63.8
4.89	6.555	4	19.68	207.1	94.5	81.5	11.5	4.26	84.9	76.5	65.0
4.90	6.565	4	19.56	207.1	93.9	81.7	12.2	4.27	84.9	76.7	65.0
5.49	7.36	4	19.68	236.7	94.5	80.5	14.0	4.81	85.8	76.2	65.3
5.51	7.38	4	19.68	236.7	94.5	81.0	13.0	4.83	85.8	76.6	65.5
4.77	6.39	5	24.15	153.5	115.8	102.5	13.3	3.97	84.8	73.2	62.1
4.735	6.35	5	24.15	153.8	115.8	102.0	13.8	3.955	84.8	74.2	62.3
5.37	7.2	5	23.86	182.8	114.5	100.3	14.2	4.625	85.7	75.0	64.25
5.39	7.225	5	24.00	182.8	115.2	101.0	14.2	4.67	85.7	75.5	64.6
6.13	8.22	5	23.8	212.8	114.3	100.0	14.3	5.37	86.0	76.0	65.3
6.105	8.195	5	23.92	212.8	114.8	100.5	14.3	5.375	86.0	76.3	65.6
6.92	9.28	5	23.86	242.8	114.5	98.7	15.8	6.06	86.2	75.7	65.3
6.9	9.25	5	23.73	242.8	114.0	98.7	15.3	6.06	86.2	76.0	65.5
5.28	7.08	5½	26.0	152.7	124.8	111.0	13.8	4.28	85.3	70.9	60.45
5.28	7.08	5½	26.1	153.5	125.3	111.0	14.3	4.305	85.3	71.3	60.8
5.94	7.96	5½	25.8	183.4	123.8	109.2	14.6	5.045	86.0	73.7	63.4
5.94	7.96	5½	25.9	183.6	124.4	109.5	14.9	5.07	86.0	74.1	63.7
6.72	9.01	5½	25.7	213.7	123.4	109.4	14.0	5.895	86.2	75.8	63.4
6.74	9.04	5½	25.8	213.8	123.8	109.5	14.3	5.905	86.2	75.6	65.4
7.57	10.14	5½	25.6	243.8	122.9	108.8	14.1	6.7	86.0	76.6	66.1
6.24	8.38	6½	30.65	156.9	147.0	131.3	15.7	5.21	86.1	72.2	62.2
6.33	8.49	6½	30.8	157.0	147.8	131.3	16.5	5.22	86.1	71.4	61.5
7.05	9.45	6½	30.6	185.0	146.9	128.5	18.4	6.00	86.2	73.6	63.5
7.06	9.465	6½	30.5	185.0	146.4	128.8	17.6	6.01	86.2	73.6	63.5
8.06	10.81	6½	30.8	216.3	147.8	127.5	20.3	6.96	86.0	74.7	64.3
8.00	10.72	6½	30.4	216.5	145.9	127.2	18.7	6.95	86.0	75.2	64.8
9.05	12.13	6½	30.8	246.5	147.8	126.3	21.5	7.86	85.8	75.2	64.75
9.07	12.17	6½	30.8	246.5	147.8	126.3	21.5	7.86	85.8	75.2	64.5
6.72	9.01	7	32.75	163.3	157.0	139.5	17.5	5.76	86.2	74.1	64.0
6.75	9.05	7	32.75	163.3	157.0	140.3	16.7	5.82	86.2	74.6	64.3
7.58	10.17	7	32.75	188.9	157.0	138.5	18.5	6.60	86.1	75.3	65.0
7.55	10.12	7	32.6	188.9	156.2	138.5	17.7	6.60	86.1	75.7	65.2
8.57	11.50	7	32.5	218.8	156.0	137.5	18.5	7.57	85.9	75.5	65.8
8.55	11.46	7	32.4	218.8	155.4	137.5	17.9	7.57	85.9	75.8	66.2
9.62	12.90	7	31.7	248.7	152.1	135.5	16.6	8.50	85.3	77.2	66.0
9.61	12.89	7	31.7	248.7	152.1	135.5	16.6	8.51	85.3	77.5	66.2
7.90	10.58	8	36.85	167.0	177.0	159.0	18.0	6.70	86.0	73.5	63.3
7.92	10.60	8	37.10	167.0	178.0	160.0	18.0	6.73	86.0	73.7	63.5
7.96	10.66	8	37.10	167.5	178.0	160.5	17.5	6.78	86.0	73.9	63.5
8.85	11.43	8	36.78	192.3	176.5	158.5	18.0	7.67	85.8	78.0	67.0
8.73	11.68	8	36.78	192.3	176.5	158.7	17.8	7.685	85.8	76.5	66.0
8.74	11.70	8	36.78	192.3	176.5	158.8	17.7	7.70	85.8	76.7	65.8
9.98	13.36	8	36.78	222.0	176.5	157.5	19.9	8.82	85.0	77.7	66.0
10.02	13.42	8	36.30	222.0	174.2	156.5	17.7	8.77	85.0	77.0	65.3
11.30	15.13	8	36.30	251.6	174.2	155.5	19.7	9.87	83.8	77 8	65 2

the results calculated from the data. The efficiency of the driving motor at normal voltage and frequency for various values of power intake was plotted and the mechanical power delivered to the pump could be obtained from this curve. The efficiency curve was obtained from careful laboratory tests of this particular motor and is not based on approximate data supplied by any manufacturer. In calculating the theoretical discharge, the full piston displacement was assumed, and the volume of the piston rod was neglected.

The results for each of six different speeds were plotted separately so that it was possible to study the effect of changing head on pump performance for any speed. It may be observed in general that the speed of the pump did not change appreciably with a given pulley, except where the motor was overloaded. The motor used in these tests was an induction motor with short-circuited rotor, giving substantially constant speed up to full load. The slip, for each speed, increases with the head, apparently in a straight line relation, as might be expected, and, in consequence, the actual discharge falls off, approximately in a straight line, as the head increases.

Regarding pump efficiency, it is of interest to observe that this item increases in all cases as the head is increased. This follows from the fact that, for a constant speed, the power delivered by the pump increases nearly in direct proportion to the head, while the losses in the pump change but little. The mechanical friction is approximately constant for a given speed and the slip increases more slowly than the discharge. The over-all efficiency curves were nearly parallel to the corresponding pump efficiencies because the driving motor has a flat efficiency characteristic, except that a falling off of over-all efficiency occurs at high heads on account of the considerable overload on the motor.

After examining the curves for each speed, the data were assembled in a different manner to show all speeds with change of head in one group of curves, figure 1. It is seen in this figure that the speed of the pumping unit remains substantially constant for a given pulley, the greatest change being with the largest pulleys. The slip curves for various speeds, figure 1, are more or less alike, showing an increase with head, but they apparently do not increase with the speed for the reason that the water flows past the valves due to the head, or pressure, and independent of the speed. The broken line shows average slip for all heads. It should be borne in

mind that slip is obtained from the difference between theoretical and actual discharge. If an error of 1 per cent is made in the

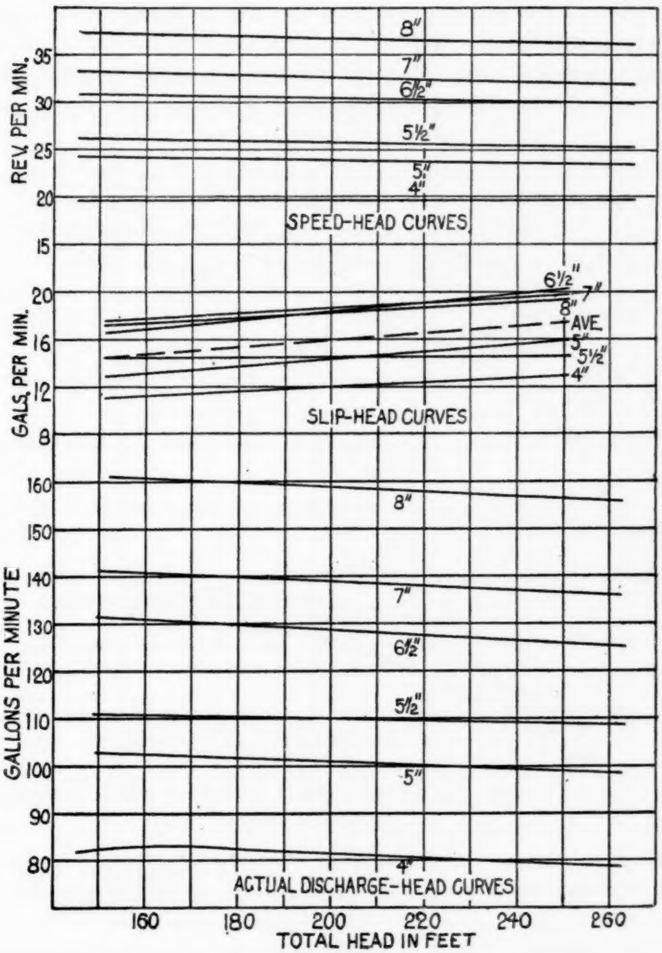

Fig. 1. Curves of Performance of Crank-Type Double-Action Deep Well Pump. Figures on Curves Show Size of Pulley Used

determination of each of these quantities, the error in slip may be greater than 3 gallons. So, in spite of the greatest possible care exercised in obtaining discharge data, the individual slip curves are

not entirely rational. The broken line, however, undoubtedly gives a reliable idea of the variation of slip with head.

The actual discharge curves, figure 1, fall off faster at high speeds, on account of overloading the motor. All are seen to be approximately straight lines.

Pump efficiency and over-all efficiency curves, plotted against head, are shown assembled in figure 2 and average efficiencies are

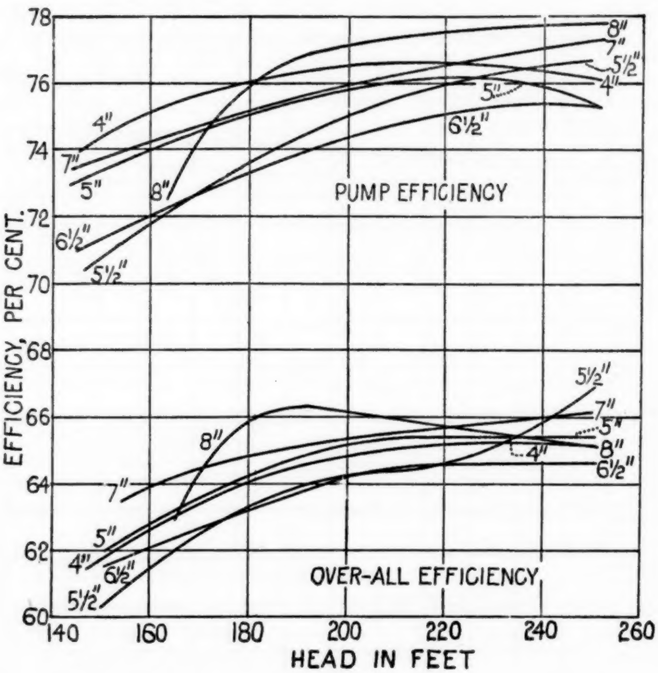

Fig. 2. Efficiency Curves of Crank-Type Double-Action Deep Well Pump. Figures on Curves Show Size of Pulley Used

given in table 2. There is an increase in pump efficiency, for a given head, principally because the slip does not increase appreciably with speed, and the over-all efficiency curves also rise with speed.

Regarding the efficiency-head curves, it is evident that pump efficiency increases approximately in direct proportion to the head. As already pointed out, this is due to the fact that mechanical

friction is substantially independent of the head and slip increases slowly with the head. By plotting all the theoretical discharge records in relation to head, table 3 can be derived from the curves for the calculation of the average percentage of slip.

Although the head is increased from 160 to 240, table 3, or 50 per cent, the average slip increases but 17 per cent, thus accounting for the greatly improved pump efficiency at high head.

Over-all efficiency curves, figure 2, are practically parallel to the pump efficiency curves, until the motor is overloaded. The motor used for these tests was 20 per cent overloaded with the 8-inch pulley and at 240 feet head. Obviously the over-all efficiency curve is dependent upon the size and design of driving motor, and the over-all efficiency curves should be practically parallel to pump curves in all practical cases where the motor is not overloaded.

TABLE 2

Average pump and over-all efficiencies

Head, feet	160	180	200	220	240
Efficiency, per cent					
Pump	73.0	74.4	75.5	75.5	76.6
Over-all	62.0	64.1	65.0	66.0	65.5

TABLE 3

Average theoretical discharges and slips

Head, feet,	160	180	200	220	240
Theoretical discharge, gallons per minute	136.0	135.6	135.2	134.8	134.3
Slip, gallons per minute	14.8	15.6	15.9	16.4	17.4
Average slip, percentage	10.88	11.5	11.73	12.15	12.95

Throughout the range of speed and head, the pump operated smoothly. There was no knock or hammer, even though the pump was considerably overloaded at high head and speed. Just what the effect would be for long-continued operation at high head and speed has not been determined at the time this paper is presented. It is safe to assume, however, that the pump up-keep would be considerably increased under conditions of maximum loading. For a large increase in speed, the authors believe this added repair expense would more than offset the gain in efficiency. In case several electrically operated pumps are in use in any system, the pumps may be speeded up to advantage in case one pump fails. Again, during a dry, hot season, it might pay to gear the pumps up

for greater output for a considerable period of time. Also, where deep wells are difficult to locate and drill, it is evident that the cost of pumping per thousand gallons might be less and thus the over-all plant efficiency might be increased by operating at speeds above normal instead of drilling and equipping new wells.

It might be well to call attention, at this time, to the possibility of meeting some very difficult war conditions by increasing the speed of pumps. While the development of some communities, due to war industries, may outgrow the pumping equipment, it is probable that delivery of this machinery will become increasingly difficult; so that extraordinary measures must be taken by the water supply companies to give satisfactory service. Higher pump speeds, at least temporarily, may prove the solution of these acute problems. The increased efficiency of reciprocating pumping units at higher speeds is also of importance when the cost of coal and the necessity of saving coal are taken into consideration.

Each individual case, of course, has its own solution, and in this article are given the results of tests made on one particular pump. These tests show results for average operating conditions, as they were made, not in a laboratory, but under working conditions in the field. The results should, therefore, be of interest to operators.

FINAL REPORT OF THE COMMITTEE ON DEPRECIATION[1]

Depreciation, as ordinarily considered in the valuation of utilities, covers all of the losses in value that occur in the plant and property, or parts thereof, from all causes whatsoever. There are, therefore, a great many considerations entering into the total allowance for depreciation as above defined.

Losses of value which are complete, and fully demonstrated by proper abandonment or necessary replacement of the whole or a unit part of a property, are a matter of history and fact, and require only proper accounting to determine their occurrence and amount.

Losses of value, which are partial or incomplete, always require prophecy as to future need, usefulness, and service, in order to properly divide that portion of the value which still exists from that which is lost. This function necessitates much more judgment than accounting. It requires the careful analysis of a broadly trained, experienced, and practical mind, thoroughly familiar with the business in question.

For convenience in reasoning, the main losses of value in an ordinary property may be divided into four groups. These are briefly described as follows:

1. Operating maintenance and repair. A part of the inevitable loss of value of any operating property consists of ordinary wear and tear. This loss can and should be continuously made good in large part by the upkeep and renewal of minor parts, paid for month by month as necessary. and should be charged to operating maintenance account. Thus accounted for and cancelled, it does not again appear as a liability.

In valuing utility plants, maintenance conditions at date of valuation should be noted. In well maintained plants, neglected repair is small; if considerable, deferred maintenance should be

[1] Read at the 1917 annual convention at Richmond, Va., and ordered printed in pamphlet form and distributed to members for discussion at next convention. Presented by title at St. Louis convention on May 17, 1918, without discussion. Printed in the JOURNAL at this time, with discussions received in writing, in order that the report may be more available than in the temporary pamphlet form in which it has remained until now.

estimated and charged. Repairs are usually going on in the ordinary operation of a property continuously. In some forms of utility plants, ordinary and rapid loss of value, which is made good by maintenance and repair, is a very considerable portion of the total depreciation to date, such, for instance, as in steam railways or electric lighting plants with heavy wear or short-life units. In other kinds of utilities, such as water works, it is comparatively small.

Examples of the more rapid type of depreciation are found in the wearing out of bearings on equipment, the replacing of small parts, re-roofing, repainting, and other miscellaneous care and expense which is constantly being made. During the many years that utilities have been operating, this loss of value has been paid for and accounted as operating maintenance. The future must be cared for in the same manner. It must not be overlooked that while this short-term replacement is paid for month by month in a well maintained plant, it is in reality a part of the whole lessening value factor, and should be so considered in the final summing up of the depreciation total.

2. Past renewals of major units. Even though the ordinary repairs are made continuously, as above described, there has been going on from the beginning a further decline in value, largely due to accumulating unfitness and changing needs to such extent that even certain major units have been in the past or must in the future finally be replaced. This culmination in larger units is reached only at long intervals, and, therefore, requires a different kind of accounting from operating maintenance.

It is known from experience that in different types of structure or machines, the useful life varies, and this can only be judged by the experience of trained appraisers. Thus useful life may be as low as five years for some kinds of electric equipment, or as high as one hundred years or more for well laid cast iron pipe under good service conditions, and it would perhaps be even longer for certain very permanent earthwork construction if future needs could be reasonably foretold. The inability of the most experienced to properly prophecy for as much as or for more than one hundred years must usually limit us to that extreme age as being all that it is wise or conservative to predict usefulness for in any case.

Where obsolescence in the past has been made good by replacement or enlargement, it, of course, should be paid for and cancelled.

Like the prior item (1), we should not lose sight of it as part of the total plant depreciation, although we do not have to again consider it in depreciation deductions yet to be made.

3. Contingent depreciation. There is sometimes an unusual drop in value in plant units on account of contingencies which were not foreseen in the past, and cannot be foreseen in the future, and, therefore, cannot be more than generally provided for in the operating revenues of a property. These losses, while usually of infrequent occurrence, are particularly trying, because almost always unexpected.

Causes which contribute to this type of depreciation are commonly accidents, such as floods, fires, tornadoes, special kinds of unusual destruction, unexpected deficiency of supply, high operating prices which affect methods, sudden changes in the art, new inventions, war effects, extraordinary droughts, personal injuries, litigation for the protection of the property, and many varieties of sudden emergency.

When these kinds of contingencies have actually occurred in the past, they have ordinarily been paid for and cancelled. Where they are recent or operative at the date of a valuation and uncompensated for, they should be subject to careful inquiry, and a special allowance made, if necessary, in addition to the regular amortization allowances hereafter explained. For the future of the property, such losses can only be met by regularly setting aside a sum annually, which experience has shown will, in a general way, cover them properly.

4. Useful life or growing functional depreciation or decrepitude. Useful life, or functional depreciation in its completed form, has already been considered in (2) "Past Renewals of Major Units." From the standpoint of upkeep accounting, we must again consider it in its uncompleted aspect. As has been said, functional depreciation describes the growing inability of the structure or equipment to adequately fulfill the changing requirements which it must meet. Functional depreciation, however, practically covers almost all of the causes which tend to shorten and limit useful life. Chiefly, these are improvements in the arts, changes in demand, discovery of more economical methods, and changes caused by growth of business. Accelerated loss of value will often be found in a utility in a rapidly growing community, where larger buildings, plant, and equipment will be required long before the original installation is

worn out or would naturally be displaced. Necessary changes often occur even when the original design and installation of the plant are still of the very best.

The service usefulness of a machine or structure rarely declines uniformly with advancing age. It often keeps well above that ratio. Also, the effect of increasing age cannot be made uniformly apparent as a fixed ratio from month to month, as is often the case with ordinary operating maintenance, but only becomes conveniently determined by special investigation at considerable intervals of some years apart, and by careful technical analysis and economic review.

This general loss of value, therefore, has been operative in the past, fractionally exists at the present, and will continue in the future until it is completed.

The above forms of loss of value from (1) Repair and Maintenance, (2) Past Renewals of Major Units, (3) Contingent Depreciation, and (4) Useful Life or Growing Functional Unfitness or Decrepitude, may be roughly divided into two classes, depending on the condition of the depreciation account, whether already determined and paid for, or as yet undetermined and unpaid for.

The First Class. Those accounts which have been determined, met, and paid for because they were visibly apparent from time to time at short intervals. This includes:

1. Past operating maintenance and repair, or such costs as have been met month by month, paid for, and charged to operating maintenance and repair account. Also contingent losses, such as have in the past occurred, been determined, and paid for.

2. Past renewals of major equipment, such as large structures or machines, the obsolescence of which took place over a considerable number of years, but when finally apparent, caused renewal or replacement, which were paid for and charged to general plant depreciation (often improperly added to Capital Account).

The Second Class. Those accounts which have not been determined or paid for, because not fully apparent. Such losses in value can only usually be determined by special investigation, as in a valuation investigation. These include:

3. Undetermined contingent loss at present operative, that is, the determination of the proper proportion of any

considerable accidental or unusual loss of value still operative or recently revealed, and as yet not corrected, which has taken place in important structures or machines.

4. Useful life or growing functional unfitness or decrepitude, that is, the present fractional part of the final complete loss of value based on the past age and remaining expectancy of useful life of the larger machines and structures.

Obviously, these latter two classes (3) and (4) require careful analysis and final determination so as to fractionally separate the amount of value remaining from the amount of value which has disappeared. The determination of value remaining always requires prophecy as to future usefulness. There is no escape from this difficult duty.

METHODS OF DETERMINING INCOMPLETE LOSS OF VALUE

The best method of arriving at the just and proper division of completed and uncompleted loss of value in plant units as yet serving some useful purpose, has been much discussed among appraisers, and pretty generally agreed upon by those who are familiar with the subject from a practical standpoint.

For Contingent Losses which are complete but as yet undetermined, it is pretty generally conceded that the cost of replacement or repair, or the cost of any unusual losses that are met with, may well be used as a guide if proper and prudent management has obtained. Where contingent losses in value are of a character that they are insidiously operating at the present time, it requires some degree of skill to properly analyze what should be determined. Reasoning deduced from cost to replace, or the use of more fit methods or up-to-date machines or proper economic balance should be applicable, and empirical decisions should be avoided if it is at all possible to carefully reason out in economic detail any of these abnormal losses of value.

LOSSES DUE TO AGE

In Growing Functional Unfitness or Decrepitude we have properly to look into the question as to how the present age and probable future useful life of a unit affects its value, and this compels us to look into all the causes which may in the future increase or lessen the need for its service.

A few appraisers insist on jumping empirically to a hasty conclusion as to future life in terms of absolute percentage without much reasoning or a proper forecast of the causes tending to maintain or destroy values. Inexperienced appraisers are hardly equipped to make a reasonable forecast at all. Such results are, of course, unsatisfactory, and do not stand the tests of analysis or cross-examination. Some appraisers, from the desire for simplicity or from motives of prejudice, attempt to assign the fractional values on the basis of the proportional life lived to the probable secured complete life, on a system of what is called "straight-line depreciation." This, of course, is a step in advance over the first crudity, but it does not yet satisfy the conditions reasonably, for, as a matter-of-fact, if the age is known and the total useful life properly agreed upon, the problem becomes a question of practical financing, modified only by a review of other factors which affect the result at the present time.

STRAIGHT-LINE DEPRECIATION

Now, so-called straight-line depreciation, or direct apportionment on the ratio of age to life, is a rough method sometimes properly used to approximate what loss of value may be allowed, particularly in very short-lived and inexpensive property, such as tools and floating equipment not worth minute analysis or careful computation, but it is obvious that with the more important and valuable structures and machines, the lives of which extend over a period of years, not only are more careful methods warranted but we must also take into account, as a practical matter, that the yearly increment set aside out of earnings for this purpose will earn interest which can be added to the principal. Certainly, in ordinary experience, annual reserve increments to a replacement fund covering years in its operation will not be put into a safety vault or a stocking.

We are, therefore, of the opinion that straight-line and sinking-fund methods of finding present worth of life expectancy are not two alternative methods, which may be selected at the option of the evaluator and indiscriminately applied to the whole problem of depreciation, but that each has its proper place and function in different fields in the same appraisement.

In life expectancy the sinking fund methods should always be applied to determine the amortization rate of important and valu-

able units, the useful life of which extends over a series of years. Such annual payments for renewal are naturally kept in reserve funds, and properly invested so as to earn interest until needed, the interest logically and properly reducing somewhat the annual payment needed for final replacement.

Straight-line depreciation, on the other hand, is an approximation only, and only has excuse when the life of the unit to which it is applied is so short, or its value so small as to not warrant careful computation on the sinking-fund principle, except that the aggregate of a large number of such items may be averaged on the sinking fund basis when possible.

Thus, most operating maintenance items paid for from month to month, or tools and supplies and possibly some short-lived units having a life of, say, five years or less, may, with judgment, be estimated on the straight line or short-cut principle without serious injustice.

It should be pointed out here that in all valuation and rate regulation questions, straight-line depreciation applied to long-lived structures is very unjust to the public, for the reason that the public in the end pays the entire depreciation bill, and if that bill is computed by methods which ignore interest, and thus set aside more annual replacement funds than are really necessary, the public will suffer the difference.

When once the important matter of determining the future useful life has been properly settled, the matter of providing for the final replacement of important structures by equal annual payments really logically draws us into the computation of an insurance policy and the determination of its present worth.

If our future useful life is correctly judged, the present worth of such an insurance policy will, in many cases, be as good an assumption as we can reasonably make for the fractional loss of value we must assign to the structure or machine for its life expectancy, especially if there is no unusual special loss (contingent depreciation) operating. It is most important to carefully determine the proper estimate of future useful life, because however the intermediate values may vary from the sinking-fund accumulation, in the end both will be practically alike if the judgment of the valuer is reasonably correct, or is kept correct by repeated reviews at suitable intervals. Future life cannot be predicted with accuracy, even with all the recorded experience available, but this uncertainty

can be practically eliminated by the correction from time to time or a re-investigation and adjustment every few years.

The majority of engineering opinion leans to the determination of losses of value arising from age and future useful life as best reasoned out from the basis of the present worth of a sinking fund, but modified by any special considerations which may exist in each special case.

A correctly computed sinking-fund consists of an amount annually paid into a depreciation reserve account, which, with its interest increment from year to year, will serve to renew and replace each structure or machine at the end of its probable useful life, and the present worth of the fund is usually assumed to roughly measure the loss of par value in a structure or machine due to elapsed life, or at least be a basis for further reasoning. Such a reserve fund is usually not actually kept in hand, but is often replaced by the owner in the property as needed. When it is made an actual fund in fact, such actual fund is really a part of the property of the utility, although it must not be forgotten, a somewhat easily detached item.

FINDING THE DEPRECIATION AT ANY GIVEN DATE

In view of the foregoing outline of the problem before us, we may suggest briefly the necessary steps in finding the depreciation of a property, it being assumed that appreciations or gains in value which would offset depreciation or losses in value are not treated of in this report.

First. Inspect the plant to see that the operating maintenance is not neglected. Where it is evidently below what good practice would require, the neglected or deferred maintenance should be estimated.

Second. Although not absolutely necessary, yet it is desirable, as a part of the work of ascertaining the full, true depreciation up to date to determine the operating maintenance account of the plant from its beginning. This account should include contingent depreciation, as herein described, wherever paid for, it being understood that in reality both items have been met and cancelled in the past.

Third. Also the replacement of obsolete major units, paid for in the past, should be audited and totaled in a similar way.

Fourth. The existing property should be reviewed to see if there are any special and unusual losses in value in any of its units at present or recently operative and unaccounted for. Where special losses in value are reasonably found to exist, they should be estimated and deducted from the unit in question before proceeding to determine its age expectancy and compute its amortization fund.

Fifth. The depreciation on small items having short lives of less than, say, three to five years, may usually be arbitrarily estimated on a straight percentage basis without much injustice, owing to the small effect of interest on the annual increment.

Sixth. In all longer-lived and important units, it is customary to determine the age to date and decide on the reasonable future life from experience with other properties and similar units elsewhere, combined with an outlook on the probable future usefulness in the case in hand.

With these data, determine the annual amount which, if set aside from the date of original installation, would, with its interest, replace the property at the end of its useful life. This annual amount will be the yearly amortization charge, and its accumulation to the present time will give a sum which if no special circumstances argue to the contrary, may usually and properly be assumed, from the financial point of view, to be the accrued loss by age alone. Finally, review the loss of value thus determined, and, all things considered, see if it is reasonable.

Seventh. Ascertain if an actual depreciation or reserve fund exists with the property under investigation. If so, find its amount and compare it with the computed amortization plus all unpaid losses of value. If it is too large, such fund should be gradually reduced in the near future; if it is too small, it must be increased annually until a reasonable balance with the investigated and determined loss of value is approximated.

Eighth. To find the true total depreciation of a property to date add (1) the Neglected or Deferred Maintenance, if any, (2) the Operating Maintenance Account from the beginning, (3) the Sum of all the Major Replacements of the past, (4) the Unusual or Contingent Depreciation, if any, as determined at date, and (5) the sum of the Accrued Amortization Funds of all the units of the property at the present time.

This is the true loss of value, in part based on fact and in part based on the judgment of the investigator, and the total thus found

should theoretically approximate the total of (1) the cash paid out in the past for operating maintenance (plus contingent depreciation), (2) the cash paid out for actual replacement, and (3) the present proper cash reserve or amortization fund of the company, if any.

Ninth. If no cash is actually on hand or is being accumulated, then the unbalanced portion of the computed depreciation, i.e., that which has not been met by cash outlay, should be deducted from the reproduction cost new, in order to get properly the present net cost of reproduction; that is to say, the reproduction of a property that is not new.

Tenth. If an amortization or reserve fund has been accumulated with a property to be used, with its increments of interest, for renewals or replacements (outside of operating maintenance), such fund should be considered as a part of the property, and should earn, in addition to its own interest increments, a general fair return from revenues, for the owner of the property derives no return from the reserve fund except as it keeps the investment at par value, a condition to which he is entitled prior to the computation of fair return.

PROVISIONS FOR TAKING CARE OF FUTURE DEPRECIATION

It is a well-recognized principle in the operation of public utilities, that the investor, whether a private corporation or a municipality, must be allowed to keep the original investment and its additions intact. Unless this principle governed, it would be impossible to secure additional capital for plant additions. It is necessary, therefore, to allow earnings to be realized which will pay all ordinary operating costs and make good all of the other losses of value above described, and, in addition, earn a fair net return upon the investment.

The determination of the proper and correct amount to be set aside in a reserve fund must always be somewhat a matter of some intelligent forecast, but, as a practical administrative matter, it is always possible to make re-adjustments from time to time as will keep the reserve fund practically just what is actually needed for the purpose of replacement.

The true total future reserve or depreciation fund should theoretically include the operating maintenance account, but, as previously explained, this is usually financed directly month by month

out of operating expenses, and if it continues to be so financed it does not have to be considered in fixing a rate for future depreciation.

Provision for caring for depreciation should, therefore, be as follows:

First. Provide for all ordinary, more or less continuous maintenance as an ordinary operating charge.

Second. Create, where possible, a separate reserve fund for depreciation, sufficient to cover all losses in value other than those covered under ordinary maintenance. Such fund should earn interest and is subject to withdrawal for replacement when needed from time to time.

Third. Test the adequacy of the reserve fund by careful technical appraisal and review its sufficiently once, say, every few years, and adjust its annual increment as seems to be necessary.

COMPUTATION OF PRESENT WORTH OF AMORTIZATION OF LONG-LIVED UNITS

The method of computing the present worth of an amortization or sinking fund for long-lived units is greatly facilitated by the use of either of the two diagrams here shown. Knowing the present age, and judging the assumed useful life from experience with other similar cases or conditions, a line leading from their intersecting lines produced downward will indicate the percentage of the accumulated amortization fund to date in terms of par value, or, in other words, the present worth of a life insurance policy for the unit under consideration.

When other influences than age are operating, they should be further considered and may cause a shorter life to be assumed than would normally be the case, or in some cases they clearly denote that it is necessary to arbitrarily lessen the par value before future life is predicted or amortization computed.

One of the diagrams presented herewith is based on a uniform interest of 4 per cent for both long- and short-lived structures, and has been used by many of the Utility Commissions. A 5 per cent rate has been recommended to the American Society of Civil Engineers, and may become necessary if money rates are materially or permanently raised by the war.

The other diagram is based on what is known as the "sliding scale," which takes into account the idea that the certainty of in-

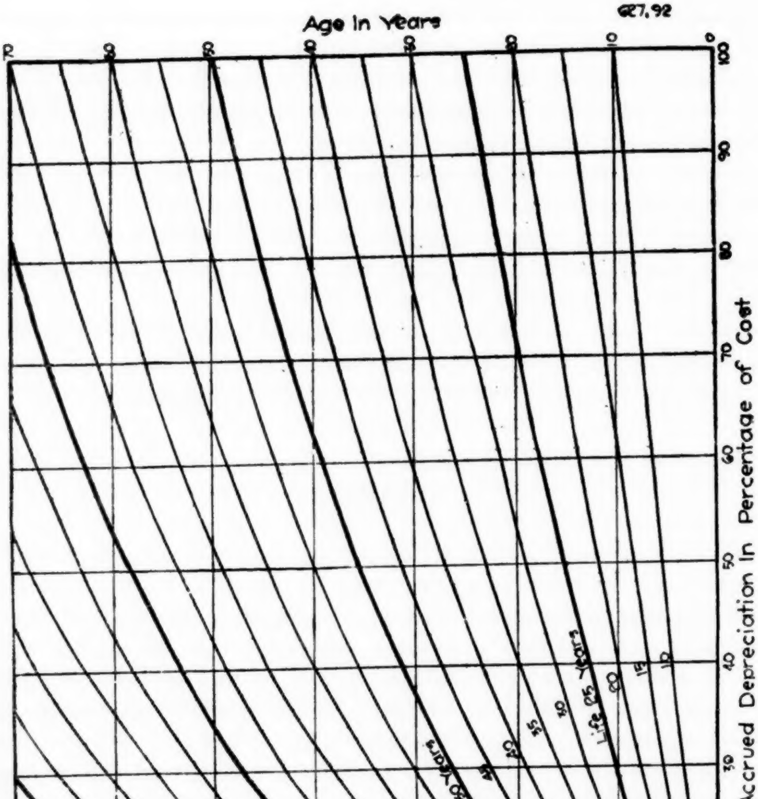

FIG. 1. DEPRECIATION DIAGRAM, 4 PER CENT INTEREST

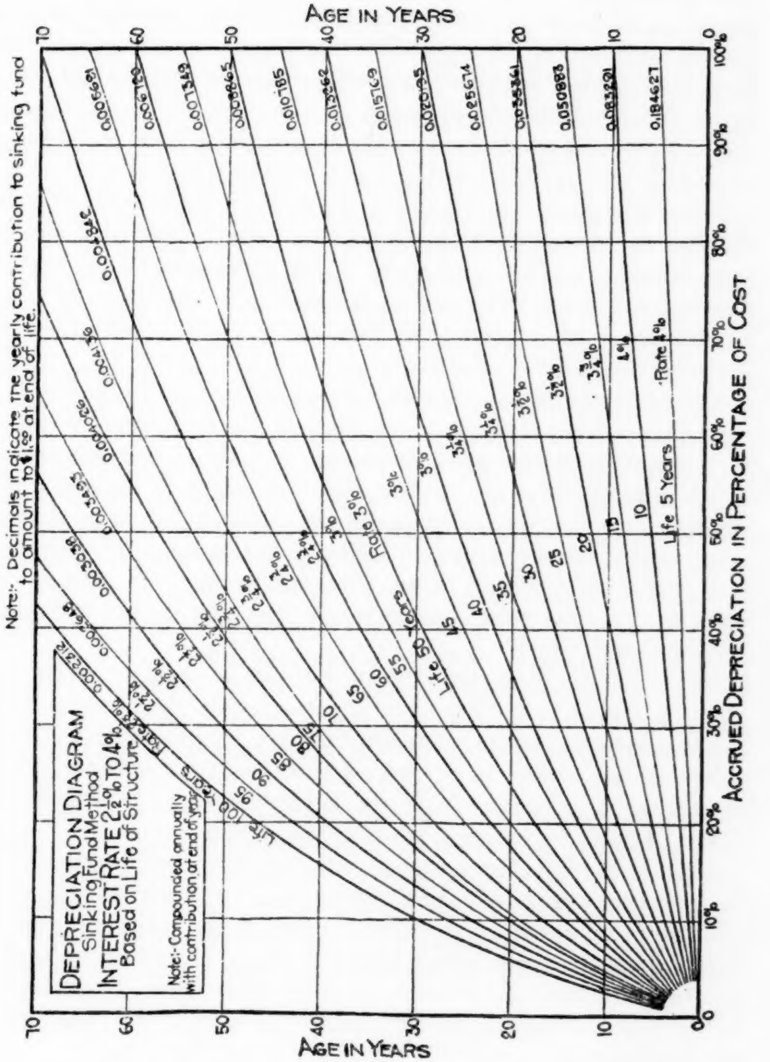

FIG. 2. DEPRECIATION DIAGRAM, 2½ to 4 PER CENT INTEREST

terest rates is not so well assured over very long periods as it is over comparatively short periods, and that long-lived structures are amortized on some less interest rate than are short-lived structures. This scale was first introduced in the Omaha appraisal, and has been often agreed to by water works engineers, but has not found favor with the Utility Commissions.

The effect of a small interest rate is to slightly increase the amortization fund and the annual payment thereto.

It is observed that the amount which is set aside annually from earnings is lowered by the compounding effect which the sinking fund enjoys. In the early years of an installation, it is usually observable that the loss of value, and especially loss of service value, is relatively small. The sinking fund in such cases tends, in a way, to follow this general condition.

The financial methods necessary to replace or amortize a structure through a sinking fund must not, however, be confounded with the service usefulness of a unit, which may in some cases keep well up to par during useful life, and in other cases rapidly drop after installation owing to poor judgment in purchase, as in contingent depreciation already discussed. The amortization fund measures only one kind of loss of value, that due to mere age, and it may differ from service value, just as service value may differ from price value or scrap value.

When useful life is correctly known, age is usually the greatest factor of value loss. But it sometimes occurs that service value loss is greater at date of valuation than life expectancy loss. When this condition exists, it is obvious that we must consider service value loss as a special contingent depreciation (as heretofore discussed) before determining life expectancy loss.

Some valuers prefer to deduct final scrap value from par value before determining life expectancy loss, or amortization. This may be done where desired, but in view of the inadequacy of the data for future scrap value, it seems to be a refinement that is hardly warranted. In extreme cases the variation of a year or two in assumed life will operate fully as well to express the judgment of the evaluator.

The estimation of the probable future life of the various parts of a plant is the real test of the judgment and experience of the estimator, for it involves an extended knowledge of the lives of similar structures under all kinds of operating conditions, as well as a local

study of the property in question. The lives of different structures vary with the class of property or equipment, the character of construction, the care with which they are operated, the thoroughness with which they are maintained, the wisdom with which the investment was originally made, and, above all, the probable changes in the future needs of the public which is served. To illustrate this, the life of boilers depends somewhat upon the quality of the water used, but more upon the future requirements for steam. The length of time which water mains may remain in service depends upon the kind of water passing through them, the character of the soils in which they are laid, the effects of electrolysis, and other physical considerations, but more than these influences is the effect upon their useful lives of the growth of the community, its drift, and the requirements of its future supply.

It is obvious that the determination and control of depreciation reserves and the proper accounting of depreciation is vital to general knowledge of the success or failure of any business in its ultimate analysis, and that the proper determination of depreciation losses, especially those requiring prophecy in the future, is a difficult and technical judicial review, which cannot be properly or justly determined by those inexperienced in water works management, operation, maintenance, and financing.

The correct determination of depreciation is, after all, a matter of sound judgment, common sense, and logical reasoning. All the aids herein outlined and suggested are only to be used with judgment to aid good judgment, but so used they are extremely valuable and helpful.

As has been stated in the beginning of this report, the determination of losses in value requires prophecy into human needs of the near future, for human needs create and maintain all values, and absence of human need destroys and depreciates all values. To prophesy future needs is not always possible, but it is more and more possible as one relies on extended past actual experience as a guide to the future.

Respectfully submitted,
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Prof. Daniel W. Mead, of Madison, Wis.
C. B. Salmon, of Beloit, Wis.
W. F. Wilcox, of Ensley, Ala.

Dissenting;
James Nisbet Hazlehurst, of Atlanta, Ga.

APPENDIX I—NOMENCLATURE

It has become increasingly necessary in valuation literature to explicitly define the meaning of words commonly employed, because a considerable number of readers are ordinarily careless about exact definition. As an instance of this carelessness, many beginners thoughtlessly associate depreciation almost wholly with wear and tear due to the fact that that phase of the subject is most apparent and the most frequently assigned, when, as a matter-of-fact, competent authority defines depreciation as loss of value arising from any cause whatever.

The following definitions will be helpful in studying and understanding this report:

1. Property. That which is owned; that which belongs exclusively to an individual; that to which a person has a legal title (whether in his possession or not); the exclusive right of possession, including all the rights which accompany ownership and is its incident.

2. Value. The property or properties of a thing which render it useful, and enable it to fill a human need.

3. In political economy, value is distinguished as intrinsic and exchangeable. Intrinsic value is the measure (usually in money) of the supply required for a human need.

4. Exchange value. Exchange value is the adjustment of two services, i.e., as between a willing seller and a willing buyer under open conditions of competition.

5. Need. A state that requires supply or relief; pressing occasion for something; necessity; want. (Webster.)

6. Intrinsic value. Inward; internal; hence; true; genuine; real; essential; inherent; not apparent or accidental. (Webster.)

7. Cost. The actual outlay of money, or its equivalent, for a property, structure, or machine.

8. Past cost. The amount of money, or its equivalent, actually expended in the past in creating and building up a property.

9. Investment. The amount of capital, or its equivalent, actually expended for a property in the past.

10. Reproduction cost. An estimate of the cost of recreating a property at the present time under conditions that are humanly possible and practical.

11. Franchise. A grant by the public of the necessary rights to do a specific business.

12. Public utility. A business supplying a public need, and based on a public grant.

13. Monopoly. A business having exclusive power of dealing in a service, and thus conducted without competition.

14. Depreciation. (1) The act of lessening or bringing down price or value.

(2) A fall in value; reduction of worth. (Century Dictionary.)

15. Obsolescence. The condition or process by which units gradually cease to be useful or profitable as a part of a property on account of changed conditions.

16. Appreciation. The increase in worth of a property, structure, or machine due to its increasing use, strategic location, the increasing need for its service, or other like influences.

17. Maintenance (operating). The act of maintaining; supporting; upholding; defending or keeping up; sustenance; support; defense; vindication. (Webster.)

18. Repair. To restore to sound or good state after decay; injury; dilapidations or partial destruction, as to repair a house, a wall, or a strip. (Webster.)

19. Renew. To make over as good as new; to restore to former freshness or perfection; to give new life to; to rejuvenate; to restore; to reëstablish; to recreate; to rebuild. (Webster.)

20. Functional depreciation. Depreciation due to inadequacy, obsolescence, and supersession.

21. Contingent depreciation. Loss of value arising from unforeseen contingencies, accidents, emergencies, and adverse and destructive tendencies exterior to the property.

22. Physical depreciation. Loss of value due to wear and tear under operating conditions, or action of the elements in non-operating conditions.

23. Deterioration. Reduction in the quality of a property unit, or in its efficiency for service due to its physical condition.

24. Accrued depreciation. Depreciation which has taken place; the completed loss of value as separated from that which is yet incomplete, usually limited to existing structures.

25. Amortization. The repayment of an original investment or debt by means of sinking funds, or other moneys set aside from time to time in expectancy of obsolescence.

26. Sinking fund. A fund created and systematically added to for sinking or paying a debt, or meeting expected losses of value. (Webster.)

APPENDIX II—THE DETERMINATION OF PROBABLE LIFE OF UNITS

The Committee have spent much time in the past in an effort to compile a card index list of known useful life of water works units, but the results have not been entirely satisfactory, and, on the whole, it is believed that it is not useful to publish this information in detail, because much of the data is obviously incomplete, inaccurate, and misleading. The Committee have therefore concluded to summarize the information only in a general way.

In fixing useful life of plant units for the purpose of amortizing their cost, it is well to remember that as the public must reimburse the utility for this loss of value before the computation of fair rates can be ascertained, there is no real dispute over the matter except to get at the facts correctly. Unreasonably large depreciations make for unduly high rates. Unduly small depreciations make for insufficient revenue. No one can be permanently interested in either of these mistakes.

Among other considerations, in fixing upon probable life it is also well to remember that prudence and conservatism suggest that, if anything, we

underestimate life somewhat rather than overestimate it, especially in short-lived units, which cannot be readjusted from time to time. The prudent owner will never unduly magnify his future stability of plant endurance, a very common optimism which often leads to serious embarrassment and even disaster.

It is further desirable to note that human needs even of the most fundamental kind, cannot be successfully predicted for more than a century, or at the utmost a century and a half ahead. In valuation work, it is always the future need of the public served that makes utility value, and this need must therefore be predicted as carefully as possible, but we are not warranted in predictions that are not reasonable in the light of past history.

The greater portion of the water works of this country has been built since 1870, a period of less than 50 years. The life of a water supply or any of its parts should not, as a matter of prudence, be estimated at too long a life; first, because it can be amortized in about a century without burden, and, second, because to predict the needs of human civilization farther than this would be to tax credulity.

With these generalizations, it is interesting to note in some detail the effect of past experience in some of the major units that enter into water works property on the probable future length of usefulness.

The following are the general conclusions of the Committee:

STORAGE RESERVOIRS AND HEAVY EARTHEN OR MASONRY DAMS, LARGE MASONRY CONDUITS AND TUNNELS

Physical. All structures of earth or earth and masonry are very durable, and in some cases reservoirs, aqueducts, and dams have lasted thousands of years. Undoubtedly such construction well-maintained is ordinarily good for some hundreds of years, physically often far outliving their functional usefulness.

Functional. All structures holding or conveying water are subject to accident from rupture, floods, burrowing animals, ice pressure, windstorms, leaks, insecure foundation, polluting influences, and malicious destruction.

Physical and contingent losses of value will be made good ordinarily by operating maintenance. This being thoroughly done, such structures should, in addition, be amortized about as follows:

Large storage reservoirs, well located..........................	75 to 150.
Heavy earthen or masonry dams..............................	75 to 150.
Large masonry conduits and tunnels..........................	75 to 150.

CONDUITS AND DISTRIBUTION PIPE OF CAST IRON OF LARGE DIAMETER

Cast iron pipe coated and buried in the ground is a very durable structure. We have little knowledge of its final effective life from a physical point of view. There are some instances of two hundred years' life for uncoated

pipe. Largely, we must amortize such durable material, kept clean and well maintained, again by consideration of the possible changes in public need, functional usefulness, and the burden of a reasonable amortization, say.. 75 to 125.

CONDUITS AND DISTRIBUTION PIPE OF WROUGHT IRON OR STEEL OF LARGE DIAMETER

Thickness of shell and sensitiveness to a greater range of deteriorating influences must of necessity bring the life of wrought iron and steel physically below that of cast iron, and in many cases below functional considerations, 35 to 75.

CONDUITS AND DISTRIBUTION PIPE OF WOOD STAVE OF LARGE DIAMETER

Ultimate experience somewhat limited, but thought to be about in same class as steel, when well protected and constantly saturated .... 30 to 60.

DISTRIBUTION PIPE OF SMALL DIAMETER

a. Cast iron. Limitations of size increase difficulties in interior cleaning and maintenance. Such smaller mains are at times removed in rapidly growing cities to make way for larger pipe. Often, they are only supplemented, 30 to 70.

It should be noted that in slow growing and smaller cities small mains are less liable to be outgrown than in larger cities.................... 50 to 90.

b. Wrought iron and steel mains. Affected by kind of water carried, soil, and coating. Liability of replacement probably greatest influence in shortening useful life.. 25 to 40.

c. Services

Wrought Iron and Steel.. 15 to 30.

Lead.. 40 to 80.

Of services, it should be noted that character of water carried, soil, and coating are influential, but changing needs are also important.

SMALL DISTRIBUTION RESERVOIRS

Physically, these structures are very permanent. Changing needs often destroy or impair their usefulness and value; they are often surrounded by growing population and increasing land value, which, in connection with decreasing need, make it desirable to abandon them. They sometimes lose value on account of need for increased head...................... 50 to 75.

STANDPIPES

Are affected by most of the influences mentioned above, and lose value in rapidly growing towns by insufficient proportional storage capacity with increased consumption. They often have value as regulators, however, long after their storage usefulness is diminished.

Wrought iron and steel.. 30 to 60.

Reinforced concrete.. 50 to 60.

VALVES

Valves physically should be amortized on the basis of the life of the valve body, the working parts being subject to operating maintenance. Fundamentally, they are more subject to change and improvement than the pipe in which they are set, and therefore should have shorter life....... 40 to 60.

HYDRANTS

Theoretically should have the average physical life of the hydrant body, the same as valves, but being in part exposed and more liable to accident and injury, and more often operated, may be considered to have somewhat shorter life than valves.. 30 to 50.

METERS

Physically they should be amortized on the basis of the life of the meter casing, the working parts being subject to renewal and repair, chargeable to operating maintenance. Fundamentally, being of delicate construction and of necessity exposed to frost, clogging, and other adverse influences and often renewed, suggested life.. 20 to 30.

PUMPING MACHINERY

Pumping machine units are functionally sensitive to changes in consumption, growth of population, improvements in the art, influences affecting source of supply, amount of use, character of water, etc., and these are the conditions that ordinarily fix their useful life.

Where function does not control physical life for amortization purposes, it should be predicated on the probable useful life of the stationary and heavier castings, all working parts being cared for annually by operating maintenance.

High duty large units.. 35 to 60.
High duty small units (say, below 6,000,000 gallons per day capacity.)
25 to 50.
Ordinary direct-acting.. 20 to 40.
Centrifugal, not geared.. 20 to 30.
Centrifugal, geared.. 15 to 25.

Boiler feed and auxiliary pumps usually take the life of the units to which they are attached.

STEAM ENGINES

About the same considerations as above........................ 20 to 40.

BOILERS

Are affected by water used, care and attention, changes in station, and changes in pressure. They may often have a long period of usefulness in reserve.. 15 to 30.

ELECTRIC GENERATORS AND MOTORS

In general, follow the reasoning on pumps, but are shorter lived.....20 to 30.

FILTER PLANTS

Now well standardized. Life should be predicated on general usefulness of station and source, as well as function of the filters themselves.

Masonry filters	30 to 50.
Wood filters	15 to 30.

BUILDINGS

Must be reviewed in the light of the probable life of the station as a whole. In rapidly growing towns they are frequently outgrown, but can often be enlarged. They lose value often in a general way because of changes in the style of architecture. Where function does not control their lives physically, it should be based on masonry walls, foundations, and roof supports; all other parts being removed from time to time by operating maintenance account.

Masonry	30 to 60.
Wood	20 to 40.

STACKS

Are limited in life to conditions of power production directly; somewhat affected by style and general appearance.

Masonry	25 to 50.
Steel	10 to 25.

APPENDIX III—SHALL DEPRECIATION BE DEDUCTED FROM COST NEW?

The economic fallacy that loss of value should not be deducted from the cost new today of an old property as a guide to finding fair present value for rate-making purposes has been recently promulgated by a few advocates, but in the face of the fact that settled practice, following earlier discussions, has agreed with the courts in always making the deduction of loss of value in old plants when valued new as of today, it would appear fair if we add the gain in value of old plants when found, to likewise deduct the loss of value in old plants when found, either from original investment or cost new as of today.

The proposition, however, has found certain favor, especially with those newly studying the art of valuation, who argue that certain utilities have different status from other utilities, but they have not yet been shown that fundamental principles of valuation differ or can differ. It is true, certain kinds of utility may have month to month replacement of short-lived units to a greater extent than some other kinds of utilities, but this does not alter the principle that losses of value should be considered as well as gains in value.

The fundamental fallacies underlying this point of view seem to be:

First. The idea that depreciation is limited to physical wear and tear, which can be made good by operating maintenance to the extent that no other kind of loss in value need be considered.

Depreciation, as shown in this report, has no such limited meaning, but covers all kinds of losses of value, such as style, changing ideas, depopulation and resulting cessation of demand for service, decreasing plant fitness as a whole. Properties are constantly rising or falling in value, and as ultimately they all die, either by parts or as a whole, it is this fact that is the most important to remember in considering depreciation.

Second. The idea is current that, in public utility valuations, it is an original investment and its additions from time to time that is being protected in an accounting fashion by the courts and commissions, rather than a review of the present status, usefulness, and need-supplying ability of the utility.

If this statement were true, then there would be no hazard to the utility business, for eventually the state, through the utility regulation, would logically and finally have to guarantee every investment against loss, dissipation, or extinction. This is not only against public policy, but it can easily be shown that it would be economically unsound and irrational for the public to undertake.

It being true, then, that depreciation covers all kinds of loss of value, including lessening need for plant service, and also true that we are not protecting an original investment mathematically, but are engaged in the more practical and useful inquiry of finding the present intrinsic value of a property today, regardless of its first cost or investment account, it follows that if we fail to follow either of the formulae for finding value:

(1) Original Cost + Appreciation − Depreciation = Present Value; or,

(2) Reproduction Cost + Appreciation − Depreciation = Present Value

we vitiate our equation and render our answer worse than useless, because it is inaccurate and misleading.

Loss of value, therefore, wherever it can be logically made apparent in old properties, must be deducted from cost new of a property as of today to find present value, just as gains in value of an old property must likewise be added to find its value now. If, in the first formula given above, the gains in value are largely lacking and have to be found and added, and in the second formula the losses of value are the most largely lacking and have to be found and deducted from cost new, it does not alter the conclusion, which ought to be the same in both cases, to be just and fair. Correct reasoning requires all losses and all gains in value to be found and added to the base cost, whether that base be past cost or present cost new. Without much hard thinking this ought to be clear as a fundamental principle of valuation and depreciation.

DISSENTING OPINION TO THE FINAL REPORT OF THE COMMITTEE ON DEPRECIATION

In presenting a substitute to that portion of the Depreciation Committee's report referring to methods of determining incomplete loss of value, as set out in paragraphs discussing "Loss Due to Age and Straight-Line Depreciation," I desire to subscribe in the main to the report as formulated by this Committee after four years of continuous effort, and it is with extreme regret that I feel forced to dissent from the belief of the Chairman and the majority of its members, and here and now to part company from so distinguished and representative a body of engineers and experts in appraisal work.

Before expressing this difference of opinion, permit me to voice my admiration for the masterly presentation and summation of ideas submitted by the committee members and as formulated by the Chairman.

METHODS OF ACCOUNTING

As an economic law, not to be successfully contended, all depreciation due to service must be met by the public some time, some place, somehow. This law is also written into the statutes (U. S. 212 l, 181).

To determine depreciation in all of its phases is not easy. The life of the parts of a water works property, or as a whole, can be approximated only and by those whose past experience and practice in engineering and management have permitted a broad experience.

A conscientious, painstaking, honest and accurate examination by a qualified observer should come reasonably near the truth. His efforts and labors will be facilitated by useful life tables compiled from past records under average conditions, contributed by acknowledged experts or from personal knowledge of the observer.

Depreciation should be spread equally over the entire life of the property and must be measured by some standard.

While several methods have been evolved, two have generally been regarded as best and simplest in practice. These are the "sinking-fund" and "straight-line" methods.

The sinking-fund contemplates payments by the customers to the company each year of such a sum as will, when invested at compound interest, amount with accretions at the end of the estimated useful life of the property in service, to the sum originally invested.

The straight-line method is simply the payment or allowance to the company each year of a sum equal to the investment divided by the number of years estimated as the life expectancy of the property.

LEGAL DIFFERENTIATION

In the valuation of the physical property of a public utility for transfer, as in purchase or sale, a conspicuous contrast is presented to its application for rate making purposes, and when so compared both in equity and in law, there is a recognized and sharp distinction.

Referring briefly to legal decisions touching this question, there is small reason to doubt that in rate cases, at any rate, the general rule seems to approve the sinking-fund method of treating physical and sometimes functional depreciation deduction.[1]

Where depreciation is one of the things to be considered in franchise tax cases, the straight-line, rather than the sinking-fund method has been prescribed by legal authorities.[2]

As a factor in accounting, some of the most advanced regulating bodies, for instance, the state of Wisconsin, have in most instances applied the straight-line plan.[3]

Besides these specific legal determinations, in purchase or rate cases, it has been said:[4]

[1] San Joaquin and Kings R. C. and I Co. vs. Stanilaus Co. (1911), Fed. 875, 881.

Cumberland Y and T Co. vs. City of Louisville, (1911), 187 Fed. 637.

Spring Valley Water Works vs. City of and County of San Francisco (1911), 192 Fed. 137.

People ex red. Kings Co. Ltg. Co. vs. Pub. Serv. Comm. (1913), 156 N. Y. App. Div. 603.

[2] Cumberland Tel. and Tel. Co. vs. City. of Louisville (1911), 187 Fed. 637, 655.

Louisville and Nashville R. R. Co. vs. R. R. Commrs. of Alabama (1911), U. S. Circuit Court, Middle Dist. of Alabama, Report of Wm. A. Hunter, Special Master in Chancery.

[3] Regulation of Railroads and Public Utilities in Wisconsin; Fred L. Holmes, p. 92.

[4] Jacob H. Goetz, Council Pub. Service Commission New York; the Utilities Magazine, Vol. 1, No. 3, P. 109.

The question of what method should be adopted in calculating the depreciation is not discussed in the purchase and condemnation cases, perhaps because the courts have used the same method that was used either by the public utility or in the decisions involving depreciation in relation to rate determination. A recent English case, after discussing the question, adopted the straight-line method.[5]

Thus it would seem that there is a distinct necessity for differentiation between the several purposes to which depreciation is to be applied, which does not seem to have received recognition in the report of the Committee on Depreciation.

From the numerous decisions cited, it can hardly be maintained that the courts more generally and widely use the sinking-fund method of figuring depreciation than any other; nor does this statement seem to square with the position taken on this subject by some of the most progressive commissions.

Attention is called to the fact that not only have the courts observed fundamental differences, but that these utility commissions have recognized the need of distinguishing or differentiating, as evidenced by excerpts from recent correspondence between the Railroad Commission of the state of California, March 7, 1916, and the speaker:

This Commission has not provided definitely for uniform use of either straight-line, sinking-fund, or so-called equal annual payment method of determining accrued depreciation.

In general the Commission is now, in establishing rates, endeavoring to provide interest upon the reasonable investment for the service rendered and a sinking-fund theoretically sufficient to replace the property when that becomes necessary. In determining value for transfer of properties or as a security for issuance of bonds or stock, the straight line method has generally been used.

Thus, under date of March 7, 1916, the Public Service Commission, Second District, state of New York, writes in part as follows:

The Commission has not as yet standardized methods of reckoning depreciation, but while requiring that depreciation should be accounted for by the companies under its supervision, it leaves to their discretion the method by which depreciation, obsolescence and inadequacy are to be estimated and taken upon their books. The Commission's recent practice, however, in cases where it seemed necessary to compute a theoretical accrued depreciation, has

[5] Natl. T. Co. vs. His Majesty's P. M. General (1913), 16 A. T. and T. Co. L 491, 538.

been to use rates for each class of depreciable property in the form of a percentage of its book cost based upon the average length of life in service under the most favorable conditions. In other words, it practically always uses the straight-line method for estimating both accrued depreciation up to any given date, and future annual depreciation charges.

As recently as April 30, 1917, in answer to the question as to "Depreciation, and how it should be accounted," the Railroad Commission of Georgia, referring to a late decision, replied in part as follows:

You will note that this Commission has approved the straight-line method. This method has been used by the Commission in practically all of the Georgia rates cases that have been up for decision within the last several years. I know of no instance in which the Commission has used other than the straight-line method.

Indeed in answer to a recent query as to how depreciation was estimated, it seems that the straight-line method has been adopted by the regulating bodies in the following states: Arizona, California, Georgia, Illinois, Idaho, Kansas, Missouri, Nevada, New York and Oregon.

The state of Wisconsin sometimes prefers the sinking fund method of determining depreciation, while Indiana is the only state where it seems to be used without qualifications.

Further, in May, 1915, these commissions were represented with the railroads in conference with the Division of Valuation, Inter-State Commerce Commission. In reply to the question by the director as to "How shall depreciation be determined," the various commissions and railroad officials, through the Hon. Milo R. Maltbee, answered as follows:

Deferred maintenance, if any, should first be determined. Age to date of appraisal and scrap value shall be ascertained and stated. Expected life shall be determined after inspection, examination of records and consideration of all factors that affect the period of usefulness. The accrued depreciation shall then be ascertained by ratio which age bears to total life applied to cost less scrap value. Deferred maintanance, if any, shall be added to this amount.

INTERSTATE COMMERCE COMMISSION

In November, 1915, the Engineering Board of the Division of Valuation, consisting of five members, at least one of whom was a practical water works operator and engineer of wide experience in

such utility appraisals, submitted to the director a memorandum (No. 226), in which Depreciation is defined as the lessening worth of physical property due to use or other causes and to be determined by a consideration of observations of actual conditions of the property and mortality statistics of similar property in like use applied when practicable on the straight-line basis.

Under date of May 4 last, Director Prouty advised the speaker that:

> The straight-line method of depreciation is employed by the Commission in stating the depreciation of railroad property under the Valuation Act.

This decision is of momentous importance considering the gigantic work of valuating the railroads of the country.

While admitting that state regulating bodies have all sorts of utilities to deal with, and that railroad property in general should be differently classed from water works plants, yet the significance of the answer given by the Director and its application to water works properties controlled by the state or in miniature along the railway lines, supplying shops and terminals, must have been understood

OPERATORS ACCOUNTING

That operators and accountants of water works use the sinking fund method, generally, can hardly be admitted or conceded. Is it not, as a matter of fact, the practice of prudently operated utility plants to lay aside out of earnings the cost of operation, including maintenance; to provide for interest and perhaps sinking fund for hired money; to pay in dividends a reasonable rate per cent? And any surplus is not hid under a mattress nor put into a stocking, nor as a rule, is it even prudently invested in a savings bank at low interest rate, but such earnings over fixed charges and operating expenses are generally spent in plant betterment.

At the time of valuation for rate making, capitalizing or purchase and sale, an accounting would naturally show that both the original investment and this surplus increment have been made in physical property, which will have visibly depreciated to an extent approximately to be determined by experts. At such times it seems reasonable to first consider that the machine whose serviceable life is half gone is worth only one-half what it was when installed new, although in point of service it may be in continuous and efficient and

economical use. Such consideration means that accrued depreciation shall be ascertained by the ratio which age bears to the total life—or the straight-line method.

ENGINEERING EXPERTS

Certainly, engineers differ radically as to the methods which should be adopted in measuring depreciation and as to how it should be accounted. In December, 1916, the Committee on Valuation of Public Utilities, appointed by the American Society of Civil Engineers, from amongst its most distinguished and expert members brought in their long-looked-for report. Their labors extended over five years, during which time forty-eight joint meetings (some of them consisting of three sessions) were held, and a voluminous correspondence filed. In presenting this report the Committee referred to the fact that the art of valuation was still in formative condition, evidenced by the conflicting views expressed or principles enunciated even by the higher courts. Referring to the matter of depreciation, the Committee says:

"Perhaps there is no single subject in connection with Valuation that has caused more trouble than Depreciation." And after discussing fundamental principles and illustrating methods of accounting, the Committee suggests three methods of measuring Depreciation as follows:

The Straight-Line Theory,
The Compound Interest Theory,
The Replacement Method,

as being three of the more generally used. Summarizing, the Committee was of the opinion that the several methods described are respectively more particularly applicable as follows:

The replacement method is applicable to those short-lived properties or parts of properties made up of a large number of items, the replacement or retirement of which proceeds after a time with fair regularity and causes no troublesome variations in return or service rates.

The straight-line method of accounting applies to any property units having more than a year of service life which are assumed to depreciate according to the straight-line theory.

The compound interest theory applies similarly to property units assumed to depreciate according to the compound interest theory.

Under either method it may be necessary to maintain a fund not invested in the property itself, as when the property is stationary or consists of only a very few large units of long life. For such properties, the sinking-fund method of accounting could be adopted if the compound interest theory is held to apply, provided it is fully understood and correctly applied, but it is not recommended.

The great discrepancy in growth of depreciation of long-lived units, under the straight-line and compound interest theories, should be carefully noted when determining which theory to use.

A CASE IN POINT

To emphasize this latter point, in a recent arbitration in which two members of this Committee participated, the depreciation of the property considered as represented by the straight-line method amounted to $743,159 while, according to the compound interest curve with four per cent allowance, $394,183 marked the accrued depreciation, there being a difference in this single property of $348,976, notwithstanding the fact that there was no dispute over the items of the physical property, their condition at the time of valuation, their life expectancy and cost new. In this particular case, where the speaker represented the city, he dissented then as he does now from the application of the sinking-fund-method to continuously operated plants where sale and purchase are being considered

OTHER PRECEDENTS

That other engineers have held similar views may be inferred from the report on the Queen's County Water Company's entire plant useful for water works. Hon. Delos F. Wilcox, Deputy Commissioner, with plant valuation $1,713,499, reported in part as follows:

Depreciation has been figured on the straight-line basis on the theory that this particular plant has reached the stage in its development where the replacements required from year to year will constitute a relatively constant item of expenditure which should be met out of an annual allowance taken from earnings rather than be charged to capital account, as has been done heretofore.

The controlling considerations in adopting the straight-line rather than the sinking-fund method in this case are, in the first place, simplicity of accounting, and in the second, the fact that the plant will never have to be

renewed as a whole and can never be brought much above, and need never be permitted to fall much below, the standard of practical efficiency now maintained. In other words, there is no call for the extremely complex and futile computations which would be necessary if we were to assume that a fund must be set aside for each individual unit of the plant sufficient to replace the particular unit when worn out or obsolete. Replacements will have to be made from time to time and although they will doubtless fluctuate considerably, perhaps even sharply, from year to year, the general average will maintain. This makes the use of our straight-line method of charging depreciation as easy as it is appropriate.

The equal-annual-payment method of charging depreciation, which has recently received considerable theoretical support, is altogether too complex to be applied to an old plant like that of the Queen's County Water Company, with an irregular past development and great uncertainty in regard to investment details.

DISCREPANCY AND COMPENSATION

While in general accord with the experience of every practical plant operator that the straight-line method is open to the practical and theoretical objection that it is not in general agreement with actual experience in the life history of water works structures other than those of very short life—its application giving considerably higher allowance for accrued depreciation in the early years of the life history of the plant than is justified by the usual actual condition of the structures, structures generally suffering small depreciation and maintaining high service value during the early years of their installation and depreciating more rapidly during the later years—the straight-line depreciation allowance method can be applied in figuring accrued depreciation upon old and well-established water works properties without injustice, and justice may be done in its application to newly organized properties, if through the agency of rates, it is possible to earn a depreciation allowance, so figured without temporary injustice to the users of the service, growing out of the fact that during the early formative years, incident to the development of the business of such new enterprises, it necessitates laying aside the larger depreciation allowance resulting from the application of this method; therefore, the effect of depreciation on plant value must be considered upon the general property rather than upon its elements. "Going Value," the cost of establishing or attaching the business, is one of those elements where cost is now generally determined along with the physical items of the works.

On the several units constituting the plant, depreciation in the earlier years is certainly negligible, while the cost of developing the business is admittedly greater, and perhaps these discrepancies may be best harmonized by a larger contribution from the consumer in the earlier years than would be actually justified if only physical depreciation was insisted upon and allowed.

EQUITY

Having dealt with questions of law and precedent, it now remains to consider the equities upon which both law and precedent must ultimately rest.

In the sinking-fund method of depreciation treatment it is assumed that the actual contribution by the customers through rates is to be set aside by the operator for the purpose of keeping the plant intact for the investors and to efficiently serve the public.

To carry out mutual obligations, it is obvious that what may be considered annual contributions to a trust fund should be prudently and productively employed with the end in view of conserving the property and performing the service at a minimum of expense.

Where this is done, accounting, rate making, or purchase cases are simply disposed of, the reserve fund with its accumulations being audited, a proper accounting in rate or tax cases can be made, or the reserve can pass with the plant to the prospective purchasers, or if retained by the utility operators, may be utilized to liquidate with the investors, the value being deducted from the property when transferred.

When simply a matter of rates, the consumer is not especially concerned with what is done with his annual contribution, especially if he is assured or assumes the rates reflect accretion, while the investor is generally satisfied to receive his annual interest with the knowledge that depreciation is being compensated for through rates.

Unfortunately, the management, called here the stockholder, is a third element in the triangle. Responsible for his own affairs and trustee for others, too often a selfish and short-sighted policy insists that private gain is not concerned in keeping up the property to a high efficiency on the one hand, or of providing adequate service at a minimum of expense on the other. Historical records are too full of unscrupulous dealings and high finance resulting in wrecked

properties and depleted service to finally terminate in enforced utility regulation by many states, some of which require that "Depreciation Account" shall be opened as a part of the operating expense to which shall be charged monthly, crediting to the depreciation reserve, an amount equal to one-twelfth of the estimated capital in the services of the utility (Wisconsin).

With such reserve to be accounted for annually, the investor and the public would naturally expect and demand that it be prudently and productively invested, and any perversion would undoubtedly be checked by the state, as contrary to public policy, if not actually dishonest.

Where such reserve is not required by law or created as a matter of sound economy by those interested in the property, it is easy to conceive that to pay dividends or to bolster fictitious stock or bond issues, improvident or dishonest operators might pervert this fund to their own use without protest so long as interest on loans was met and a fairly satisfactory service performed under a reasonably acceptable rate.

ACTUAL CONDITIONS

But a very different condition is created when at the end of any contract period, the public determines to assume ownership by purchase or condemnation. Up to this time the operating company, called the stockholder, hiring the capital from the investor for the services of the consumer, is in fact the agent of those parties at interest to whom now must be rendered an accounting of his stewardship.

Too often this settlement reveals the fact that, although collected for such use, no reserve or depreciation fund was ever put aside and that there are no accretions. To cover this admission and explain the deficit, an ingenious evasion is the assumption by those authorized to represent the management that a deduction of a hypothetical depreciation fund would entirely satisfy the demand at the time of the accounting.

If we appeal to the law, we learn from Mr. Justice Moody, presiding in the celebrated Knoxville case, that true values "cannot be enhanced by a consideration of errors in management which have been committed in the past," the decision being an estoppel of an attempt to create a value which should have arisen from sound financing, when the initiative by the management is proven to have

been lacking or where the facts are fairly conclusive that this trust fund, instead of having been productively used by those to whom the reserve has been committed, had been misapplied to their own selfish ends, either as stock dividends or to inflated capital issues, no part of which have been returned to the property.

ILLUSTRATION

A somewhat analogous and familiar illustration of the working of these fallacious principles may be afforded by conceiving that the nominal owner and manager of mortgaged property had been required by the investor to collect from the tenant an annual sum sufficient to protect the building and contents from fire, but, while receiving from the source a sum equal to the annual risk, the manager had misapplied these contributions to his private use instead of taking out an insurance policy as stipulated by the investor and meeting the premium that had been advanced by the tenant.

So long as nothing happens, there is no complaint, but when the crisis comes and a fire loss must be met, the now anxious investor and tenant find that the property is uninsured. That the manager then insists that the full amount of the insurance should be credited in the settlement after deducting the premiums paid and the accretion that had not been earned on the reserve, would hardly satisfy either investor or tenant, and such application of this hypothesis to water works transfer case is no more convincing to others. Therefore the writer is constrained to dissent emphatically from the viewpoint of the majority members of the Committee touching such cases.

COMMITTEE REPORT

In that portion of the Committee's report dealing with "Loss Due to Age" the following is in part asserted: "Some appraisers from the desire for simplicity, or from motives of prejudice, attempt to assign fractional values on the basis of the proportional life lived to the probable assumed complete life, on a system of what is called 'Straight-line Depreciation.' " Again, referring to a few appraisers who insist upon "jumping to a hasty conclusion as to future life in terms of absolute percentage without much reasoning or a proper forecast of the causes tending to maintain or destroy values," the inference is that such "inexperienced appraisers" are hardly equipped

to make a reasonable forecast at all, and coupling those individuals with those who use the straight-line process, the distinction is that the last "is a step in advance of the first crudity."

Most emphatically does the speaker protest against the assertion that the straight-line method is only *used for its simplicity,* while it is little short of an insult to those distinguished jurists, publicists, accountants and engineers who have been quoted as preferring the straight-line method under certain conditions to impugn their motives or for a moment suggest that they used this method of accounting depreciation through motives of prejudice.

Therefore substitution in the final report of the Committee on Depreciation, for the paragraphs in the section on "Methods of Determining Incomplete Loss of Value," relating to *Losses Due to Age* and *Straight-Line Depreciation* of the following is recommended:

GROWING FUNCTIONAL UNFITNESS OR DECREPITUDE

In growing functional unfitness or decrepitude all causes affecting longevity, life expectancy and future needs for particular machines or structures, as influenced by local conditions, should be reviewed as a means of determining present fractional loss of value.

Depreciation thus considered extends over the entire life of the parts constituting the property, and must be measured by some standard. Of several criterions now in general use, the two most favorably regarded by recognized authorities in valuation work are commonly known as the "sinking-fund" and the "straight-line" methods. While either method may be selected, provided only that under the circumstances it is legal, safe and fair, the great discrepancy in the growth of depreciation of long-lived units under these two theories should be carefully noted when giving a preference to the use of either.

The Sinking Fund contemplates annual contributions of such sums as will, when prudently invested, amount with accretions at the end of the useful life to the original sum expended.

The Straight-Line theory is an assumption of payment or allowance each year of operation, of a sum equal to the total investment divided by the number of years of actual life or expectancy, and generally expressed as a percentage of the whole; it is the direct apportionment on the ratio of age to life. This yardstick measuring depreciation is universally serviceable and approximately accurate

for determining loss of value of short-lived or inexpensive units of a public utility works and may be used with discretion under certain other conditions, and may apply especially to such as depreciate with uniformity from the beginning to the end of service lives.

In transfers of property by condemnation or sale, where depreciation has been a factor in determining the net income representing a rate return, and when depreciation is one element to be considered in franchise tax cases and even for public accounting, the courts and regulating bodies have sometimes permitted or prescribed the straight-line method.

In the actual operation of a public utility the use of this method is open to the theoretical and practical objection that it is not in substantial accord with actual experience in the life history of units assembled in such works, other than those of exceptionally short life. Its application under such conditions gives considerably higher allowances for accrued depreciation in the early years than would be justified by the real condition of units under consideration. These in the main suffer only slight deterioration while maintaining high service value at first and depreciate more rapidly during the last of their life cycles; nevertheless, in old and well established properties when replacements constitute a relatively constant expenditure, the application of the straight-line principle is possible without doing violence to the equities and is not against public policy in such cases. Moreover, justice may be done to all interests where the straightline practice is observed for measuring the depreciation of even newly organized properties, if through the agency of rates an allowance to cover is permitted and earned without prejudice to the users of the service.

This is true for the reason that during the early formative years the development of the business requires larger proportionate contributions from customers although the physical depreciation during the corresponding period is admittedly less. Now, since, the cost of establishing the business must be paid by the public some time, some place, some how, discrepancies between these two operating costs may thus be substantially reconciled. For actual operation, such allowances might be prudently invested and in this event it takes on the characteristics of the Sinking Fund, being in fact a reserve productively used.

The Sinking Fund provision, with the use of the compound interest curve, is of especial application to rate cases, offering a con-

venient and reliable method of accounting, fully justified as well by both law and precedent.

When the age of any part of a plant can be determined and its useful life agreed on, the problem becomes one of practical finance, modified by special influences at the time of consideration.

With the more important items whose life expectancies cover considerable periods of time, precise methods of accounting are highly desirable, and in such cases economy demands, business prudence requires and courts have decreed that an annual increment shall be set aside out of earnings through the agency of rates as a reserve or "sinking fund" whose purpose is to replace no longer useful parts at the end of their natural lives, thus insuring continuous and efficient service while keeping original investments intact.

To make these provisions the sinking fund method seems best in both theory and practice.

For a clear conception of its functions, the familiar insurance policy, its purposes, its computation, its annual payments and every day determinations of its present worth may be cited as a preliminary basis for reasoning. Considered an insurance against loss, a correctly computed sinking fund consists of an amount annually paid into a reserve account which with its interest increment from year to year should serve to replace the structure or machine at the end of its probable useful life, and the present worth of this fund in some cases may be assumed to measure the loss of par value in such unit.

While such a reserve fund need not always be kept as cash in hand, and indeed may often be more productively invested in plant betterment, it is part of the property being considered and where so found will offset to the extent of the audit any depreciation in plant value, but when neither present as a cash asset nor returned to the plant as a betterment, no legerdemain of high finance or tricks of bookkeeping should becloud the issue, since true values can "not be enhanced by a consideration of errors in management which have been committed in the past," and no deduction of a hypothetical depreciation fund will satisfy the demand at the time of the accounting.

Therefore, where a property is being appraised for transfer of ownership, equity seems to demand that depreciation shall be ascertained by ratio which age bears to total life applied to cost, less scrap value; and deferred maintenance, if any, should be added to

these amounts, or should be recognized and allowed for in general terms.

Since depreciation is the act of lessening or bringing down price or value, resulting in a reduction of worth, in such cases the lessening worth of physical property can best be determined from visual knowledge of actual conditions tested by mortality statistics of similarly circumstanced property, applied where practicable on the straight-line basis.

James Nisbet Hazlehurst.

DISCUSSION

Clinton S. Burns: The writer is pleased to acknowledge his appreciation of the very thorough work of the Committee on Depreciation as manifest by its final report. The writer sees but little to add to this report in the way of discussion, but takes this occasion to emphasize one of the points mentioned in the Committee's report in substantiation of its reasons for adopting the Sinking-Fund Method in preference to the so-called Straight-Line Method of depreciation.

It seems to the writer that the principal stumbling block in the way of the universal acceptance of the Sinking-Fund theory of depreciation is perhaps the fact that the relationship between finance and depreciation is not always clearly understood. The fallacy in the straight-line theory of depreciation is that it ignores one of the elements of cost, namely the cost of money, and this forms a vital part of every business transaction.

The determination of the physical condition of the property is but one step in computing its present value; those who stop there are content to rest with the unfinished problem. Beyond this step comes the problem in finance, to compute the relationship between physical condition as determined by age and life and the present value as determined by the laws of finance. A property having 50 per cent physical condition may not have a 50 per cent financial value, and in fact never does, unless it is a property that can be paid for on the installment plan in direct proportion to its use, at the same price as though paid for in advance. This is a fundamental principle of finance, but appears to be a stumbling block sufficient to baffle the advocate of the straight-line theory of depreciation.

If pumps, engines and other property could be purchased at their cash price, and paid for annually in proportion to their use, then the straight-line theory of depreciation would be correct; but for all property that must be paid for cash in advance, or its equivalent, physical condition does not measure present value, but bears a certain relationship thereto, that can be computed by applying the necessary financial factor to complete the problem.

Now, to make this point more apparent, suppose that in the appraisal of a water works property that it be found that the pumps, engines, pipes, buildings and other physical structures are one-half worn out, that is to say, their physical life of service is half expired at the time of appraisal, and suppose that among the items of property there be found a life insurance annuity likewise one-half paid out, that is to say, its physical useful life is half expired. Now every one familiar with problems of finance would immediately turn to his annuity tables, in order to compute the present value of this life insurance annuity. For example, if it were an annuity having forty years to run, bearing 4 per cent, and it were not half paid out, or in other words twenty years of its life were expired, it would be found from the annuity tables that the present value of this policy is 69 per cent of its face value, that is to say it is only 31 per cent depreciated.

Now suppose the next item of property were a pump having a life of forty years, twenty years of which had expired, can there be any possible reason to urge that a different formula should be applied to determine the value of this pump from what has just been applied to determine the value of the life insurance annuity? Both are items of property and the relationship between physical condition and financial value is in both cases the same, the only difference being that in the case of the insurance annuity the rate of interest and the total life were both definitely predetermined, while in the case of the pump the length of useful life and the proper rate of interest to apply are left to the discretion of the appraiser.

If those who have difficulty in understanding the fundamental principles and the justice of the Sinking-Fund Method of computing depreciation will keep clearly in mind the fundamental relationship between finance and depreciation as demonstrated in the example given above, of the life insurance annuity, all of their doubts and misunderstandings will immediately be removed, leaving nothing in the way of the universal adoption of the Sinking-Fund Method.

W. E. MILLER: The attitude of the Railroad Commission of Wisconsin (which is a public utility as well as a railroad commission) toward depreciation and the manner of providing for it is likely to be entirely misunderstood from a broad general statement and foot-note contained in the minority report from a member of the Association's Committee on Depreciation. It is there stated: "As a factor in accounting some of the most advanced regulating bodies, for instance, the State of Wisconsin, have in most instances applied the straight line plan." The author of the minority report cites "Regulation of Railroads and Public Utilities in Wisconsin," by Fred L. Holmes, as authority for this statement.

Halford Erickson, a former chairman of the Wisconsin commission, and the man who served longer as a member of it than any other and who had most to do with the commission's studies and determinations of property value and depreciation, presented a paper on the subject of Depreciation before the convention of the Central Water Works Association at Detroit, Michigan, September 25, 1912. The subject was therein discussed at considerable length. That the views therein stated represent those of the commission may easily be demonstrated by reference to their numerous decisions wherein special attention is given to depreciation.

In the above mentioned paper the author admits that "the straight line method is much more simple and direct than any of the other methods. It is advocated by the Interstate Commerce Commission, and for certain purposes also by the Wisconsin and other state commissions." This statement was made about five years after public utility regulation was inaugurated in Wisconsin. It is to be taken in connection with the fact that much more use was made of and more weight was given to the straight line method by that commission during the first five years than during later years. Note that Mr. Erickson admits the use of the straight line method by the Wisconsin commission only for *certain purposes*. Even during the first five years of its public utility work that commission did not make general use of it.

The Wisconsin commission has relied very largely upon its engineering staff for determinations of values of physical property of utilities, yet the staff's estimates were always "tentative" and subject to whatever corrections the commission might find to be warranted in view of evidence submitted by interested parties during public hearings. It can be positively asserted that in almost

every case the staff's estimates, both as to reproduction cost new and accrued depreciation of utility properties, have been substantially accepted by the commission after hearing such objections and criticism of them as were offered. It can also be asserted with equal assurance that the staff's estimates on accrued depreciation have in practically all cases been on the sinking fund basis. The adoption of this basis assumes that the depreciation of property is fairly well measured by the state of the fund built up throughout the life of the property, as estimated, and that such funds earn and are credited with interest at an easily obtainable rate, all designed to equal the original investment at the end of the life of the property.

The Wisconsin public utilities law expressly provides that every public utility shall establish a depreciation reserve and that the earnings of the depreciation funds shall be credited to them. (Wisconsin Statutes, Sec. 1797m-5). This in itself may be considered as a legislative recognition of the soundness of the sinking fund method of providing for such part of the cost of furnishing service.

Both the straight line and the sinking fund methods call for a uniform annual appropriation to the depreciation reserve, out of earnings, for a constant property value. The increasing rapidity of accumulation of that fund by the latter method is due to the addition and compounding of interest earnings.

In discussions of the methods of providing for depreciation apparently but little has been said concerning the proper treatment to be accorded to the interest earnings of the depreciation funds by the advocates of the straight line theory. Certainly these funds cannot reasonably be expected to be idle. The most logical place for the obtainable earnings of such fund is the fund itself.

In the case of a sale of depreciated property and the retention of the depreciation reserve funds by the seller, the buyer would be under the necessity of making materially increased annual appropriations out of gross earnings to provide for depreciation, since he would be deprived of the interest earnings of the funds accumulated for that purpose previous to the transfer of ownership. In such case the application of the sinking fund method of estimating accrued depreciation, in the same manner as would be done in a valuation made for some other purpose, might be rather inequitable.

To show the effect of the separation of a depreciation reserve fund from the property in such a case as that alluded to above, let it be assumed: (1), that a plant having an estimated composite

life of 50 years is to be sold when it is 20 years old; (2), that there is no material difference between the actual original cost and the estimated reproduction cost new of the physical property; (3), that an approximately correct depreciation fund has been built up from the beginning of operation on the sinking fund basis, with interest earnings at 4 per cent. The annual charge for depreciation for each dollar of investment in depreciable property is

$$a = \frac{\$0.04}{(1.04)^{50} - 1} = \frac{0.04}{6.104} = \$0.00655$$

The amount of the depreciation fund, per dollar of investment, in 20 years, when the transfer takes place, is,

$$\frac{(1.04)^{20} - 1}{(1.04)^{50} - 1} = \$0.1951$$

So far as the remaining or present value is measured by the result of deducting the depreciation reserve from original cost or cost new, the remaining value for each dollar of original investment in depreciable property is $\$1.00-\$0.1951=\$0.8049$ on the 4 per cent sinking fund basis as against \$0.60 on the straight line basis. If the fund does not remain with the property after the transfer, the latter amount is to be amortized in thirty years without the help of the compounding interest on the previous accumulations. By proper computations it will be found that in order to do this the annual charge against gross income, on account of depreciation, will be increased from \$0.00655 to \$0.014356 per dollar of original cost new. This is an increase of 129 per cent for this particular case. This consideration of this assumed case is purely mathematical. It is far from the writer's intent to imply that valuations of property including determination of depreciation, are merely matters of mathematics. What the Association's committee on depreciation has said on the need for wide experience and good judgment in the appraiser of property is fully appreciated and heartily approved.

In conclusion, and in respect of the original writer's purpose—to correct a possibly false impression as to the methods and practices of the Wisconsin commission concerning treatment of depreciation—it may be firmly asserted that although that commission has heretofore followed the so-called straight line method in certain cases

and for certain purposes, it has much more generally applied the sinking fund method, especially during the more recent years. This could be demonstrated by a perusal of its published decisions. These statements are made on the basis of the writer's connection with that commission throughout its public utility work to date.

A few citations of and extracts from decisions by the commission may be of sufficient importance to warrant their presentation here, but a few only will be given.

A proper depreciation reserve is required of all utilities. A distinction, however, should be drawn between a depreciation reserve, which is required, and a depreciation reserve fund, which is optional. The fund is created by actually setting aside cash or other assets out of which future payments are to be made. A reserve is merely an account which designates the amount and character of certain transactions within the business. (In re Application Fennimore Mun. W. & Lt. Plant, 1913, 12 W. R. C. R. 194, 209.)

It is not usually necessary for any utility to keep the off-setting assets to care for depreciation requirements in actual cash on hand. The assets for this purpose may be represented in plant, in current assets such as cash, or in a combination of the two. (In re Appl. City of Sparta, 1913, 12 W. R. C. R. 532, 540.)

Amount of annual charge. An estimate of the proper amount yearly to be contributed to the depreciation reserve must take into consideration the life of each separate unit of equipment, its value, the interest that the reserve will earn before it is used to pay for replacements, and the amount that will be realized for scrap value when it is discarded. (In re Men. & Mar. Lt. & Tr. Co., 1909, 3 R. C. 778, 846; Hill et al. v Antigo Water Co., 1909, 3 R. C. 623, 643; State Journal Prtg. Co. et al. v Madison Gas & El. Co., 1910, 4 R. C. 501, 599; Lamb v. Eastern Wis. Ry. & Lt. Co., 1911, 6 R. C. 473, 485; King et al. v. Wis. Tel. Co., 1912, 10 R. C. 517, 521; In re Invest. Ashland W. Co., 1914, 14 R. C. 1, 45, 46; Jones et al. v. Berlin Public Service Co., 1914, 15 R. C. 121, 129.)

Amount of flat annual charge in case the depreciation fund earns interest. In case the depreciation fund can be made to earn a fair rate of interest, the amount of the flat annual charge can be decreased in proportion to the amount of the earnings on the depreciation funds. (In re Badger Tel. Co., 1908, 3 R. C. 98, 99, 101; City of Ashland v. Ashland Water Co., 1909, 4 R. C. 273, 279–281; State Journal Prtg. Co. et a.l v. Madison Gas & El. Co., 1910, 4 R. C. 501, 611–612.)

Determination of annual charge and composite life. The average life and the annual amounts required to make up the depreciable plant values, are estimated on two bases—the so-called compound interest curve or "sinking fund" basis and the straight line basis. (State Journal Prtg. Co. et al. v. Madison Gas & El. Co., 1910, 4 R. C. 501, 604; In re Appl. Ft. Atkinson W. & Lt. Comm., 1913, 12 R. C. 260, 285.)

Determination of annual charge—Basis of charge. The property value upon which the depreciation allowance must be based, or, more properly speaking, the amount which the estimated yearly reserve should in the end equal in a period of years approximating the average life of the plant, is the cost new of the depreciable property. (State Journal Prtg. Co., et al. v. Madison Gas & El. Co., 1910, 4 R. C. 501, 601.)

Difference between two methods with respect to practical application. Where the life of a utility is comparatively short and where advances in the art are numerous as in the case of an electric plant it would seem that the sinking fund method of determining depreciation would be more or less impracticable and difficult of application. On the other hand it would seem that the sinking fund method is to be recommended in the case of water utilities, as more exactly corresponding to the actual experience of such plants and as more economical and satisfactory in the long run. (In re Fond du Lac Water Co., 1915, 5 R. C. 482, 503.)

The practicability of obtaining interest at an average rate of as much as 4 per cent on funds which are frequently drawn upon and added to is of sufficient doubt to lead to the assumption and use of a more conservative rate. The amounts set aside annually for depreciation must increase with the magnitude of the depreciable property, although perhaps not in exactly direct proportions. (In re Invest. Ashland Water Co., 1914, 14 R. C. 1, 46.)

Under the sinking fund method. Under the sinking fund method for determining depreciation it is assumed that the amount set aside annually should be invested at compound interest, and that the amount so set aside, plus the interest, will be sufficient to cover the replacement at the end of the life of the property. (Hill et al. v. Antigo Water Co., 1909, 3 R. C. 623, 643; State Journal Prtg. Co. et al. v. Madison Gas & El. Co., 1910, 4 R. C. 501, 604; City of Ripon v. Ripon Lt. & W. Co., 1910, 5 R. C. 1, 20; In re Fond du Lac Water Co., 1910, 5 R. C. 482, 503; City of Racine v. Racine Gas Lt. Co., 1911, 6 R. C. 228, 296; Schicker v. Rockford & I. R. Co., 1911, 6 R. C. 695, 709.)

It does not seem fair to allow a continuously operating property an expense for financing depreciation on a straight line basis. A large company with a number of joint utilities and subsidiary properties under its control and with numerous opportunities for commercial investment, can readily invest any offsetting assets of the depreciation reserve liabilities at an average of 4 per cent return or better. (In re Service of T. M. E. R. & L. Co. in Milw., 1913, 13 R. C. 178, 227–228.)

Differences between straight line method and sinking fund method of determining depreciation. Under the straight line method of determining depreciation, the drop in value is the same each year during the entire life of the unit. Under the sinking fund method the drop is light at first, while the amount set aside is small but the drop in value increases as this amount grows larger, and toward the end of the life period it rises quite rapidly. For short life units the difference between the two methods is probably not very material. For long life units, on the other hand, the difference may be of importance. (Hill et al. v. Antigo Water Co., 1909, 3 R. C. 623, 643–644.)

Necessity for reserve charges. To ward against depreciation not covered by current repairs a depreciation reserve must be carried on the books of the company. Wis. Statutes sec. 1797m-15. Another reason why this reserve is so indispensable is that it equalizes depreciation charges. (Knapp et al. v. Matteson Tel. Co., 1912, 11 R. C. 180, 192; In re Appl. Merrill Ry. & Ltg. Co., 1907, 2 R. C. 148, 154; In re Invest. Mosinee El. Lt. & P. Co., 1914, 13 R. C. 712, 714; In re Invest. Ashland Water Co., 1914, 14 R. C. 1, 45.)

Purpose of reserve. The aim of the establishment of a depreciation reserve, in short, is to keep the original investment intact. (In re Appl. Cumberland Mun. El. Ltg. Plant, 1909, 4 R. C. 214, 217; City of Whitewater v. Whitewater El. Lt. Co., 1910, 6 R. C. 132, 135; In re Appl. Columbus W. & Lt. Comm., 1913, 11 R. C. 449, 456; In re Appl. Fennimore Mun. W. & Lt. Plant, 1913, 12 R. C. 194, 209.)

Total renewals should amount to total depreciation in long run. In the long run the total renewals should amount to as much as the total depreciation, but for any given period there may be wide differences between them. (State Journal Prtg. Co., et al. v. Madison Gas & El. Co., 1910, 4 R. C. 501, 560.)

In general. It is probable that the fairest representation of the course of depreciation is the sinking fund curve. Whether a 4 per cent, 3 per cent or other curve is the closest to a fair and reasonable rate depends largely upon other factors, which can perhaps be closely ascertained only by careful investigations and clear knowledge of the surrounding conditions. (City of Beloit v. Beloit W. G. & El. Co., 1911, 7 R. C. 187, 236.)

As the rate of depreciation depends on the useful life of the property, it can readily be determined when this life and cost of the property are known. (State Journal Prtg. Co. et al. v. Madison Gas & El. Co., 1910, 4 R. C. 501, 559.)

The commission's "Uniform Classification of Accounts for Water Utilities" contains the following:

Depreciation reserve. To this account shall be credited monthly, or as they are made, all charges to the Depreciation Account (hereinbefore described), the income from the investment of any money or from any security belonging to the Depreciation Reserve, and any other appropriations which may have been made to it.

When through wear and tear in service, casualty, inadequacy, supersession or obsolescence, any building, structure, facility or unit of equipment originally charged to capital is no longer economically reparable, and in order to keep the productive capacity of the plant up to its original or equivalent state of efficiency it is necessary to make a complete replacement of such building, structure or unit or equipment, the money cost of the original unit replaced and charged to capital (estimated if not known, and if estimated, the basis thereof shall be shown in the record entry) shall be charged to the Depreciation Reserve, and the excess cost of the substituted unit over such original unit shall be charged to the appropriate capital account.

When any building, structure, facility or unit of equipment originally charged to capital is retired from service and not replaced by any other unit of similar nature or equivalent thereto, the original money cost thereof (estimated if not known, and if estimated the basis thereof shall be shown in the record entry) shall be charged to this account and such amount originally entered or contained in the charges to capital in respect to such unit so being retired shall be credited to the capital account to which it was originally charged, and any adjustments necessary made through the Surplus Account.

The salvage or scrap value of any unit of equipment retired from service or replaced by any other unit will be credited to this account.

An analysis of the charges and credits to this reserve will be called for in the annual report to the Railroad Commission.

From all of the foregoing it can scarcely appear that the Wisconsin commission has neglected the effect of attainable earnings of the depreciation reserve or that it has inclined very strongly toward the straight line basis of estimating depreciation.

LEONARD METCALF: The writer is exceedingly glad that W. E. Miller, chief engineer of the Wisconsin Railroad Commission, has submitted to the American Water Works Association, through its JOURNAL, an authoritative statement concerning the practice of the Wisconsin Railroad Commission in determining and accounting depreciation of public utility properties, correcting the false impression concerning the attitude of this Commission upon this question, which would be gained by reading the minority committee's report.

In the interest of preventing further errors in assumption, the writer calls the attention of members of the Association to other fallacies contained in this report which were called to the attention of the author of this report before its publication, but which were probably overlooked under the pressure of more important obligations.

The comment of the minority report upon the practice of various commissions and the rulings of certain courts is unfortunate, as it fails to recognize the very important fact that the practice in accounting the depreciation of railroad and other like properties, has no significance with reference to water works properties. The discussion fails utterly to bring home to the reader the essential difference in treatment necessary with respect to long-lived property as compared with short-lived property. Moreover, a simple citation of the attitude of different State commissions, some of which

have had little or nothing to do with water works properties, as a matter of significance, without discrimination or comment upon the real significance and importance of the final conclusions of a man like Halford Erickson, formerly of the Wisconsin State Commission, is most unfortunate. It is of no significance to be told that the Public Service Commission in a certain State uses the straight line depreciation method when its rulings have been limited to the properties of railroads.

On the other hand, it is of great significance that as a result of diversity of experience, sifting of evidence and sound analysis, a man like Mr. Erickson finally concludes, as stated by him in an address on "Depreciation and its Relation to Fair Value" delivered before the Conference of City Mayors and others interested in public utility control, held in Philadelphia in November, 1915:

> Much has been said about the relative merits of the straight line and sinking fund methods of providing for depreciation. Without going into details in this matter it can be said that the sinking fund method implies a more efficient use of the reserves. It also seems that, because of such use, the amount the customers will have to contribute to cover depreciation is less under the straight line method. *The inference that can be drawn from these facts is that the sinking fund method is the most economical and hence would also seem to be the best of the two methods from the point of view of public interest.*
>
> In this connection it may be in place to repeat in substance something that has already been said. All virile and live enterprises are constantly in need of readily available funds for various more or less temporary uses. The ability to quickly obtain such funds often stands for material savings in more respects than one. For these and other reasons it may not be in line with the best policy to place too many restrictions upon the balance in the depreciation reserve.

And it is of further significance that he and his associates upon the Wisconsin Railroad Commission should long have discriminated clearly between the effect of long and short life and character of property upon the necessary and fair allowance for depreciation.

Important, too, is the fact that the minority report does not recognize the lessons taught by the application of the several theories of depreciation to long-lived properties, the historic records of which have been fairly established. These seem to show clearly in their record of abandoned property and condition of existing property the gross unfairness of determining accrued depreciation by means of the straight line formula, particularly as applied to water works properties by its advocates.

And finally, the minority report fails to recognize the equities of the situation so judicially set forth by Hon. H. M. Wright, Standing Master in Chancery of the United States District Court of the Northern District of California, in his decision on the Spring Valley Water case in 1917:

> In other words, the plaintiff's capital must, on ————'s estimates, by a change from the replacement method of cost-accounting, suffer a deduction of at least three and one-half millions, which the public ought to have paid in the past but did not. Shall that cost be increased to nearly eight millions merely by a choice of a theoretical mathematical method of amortization? *As I said in the report in the Contra Costa case, if I were to decide the question of present depreciated value by reference merely to formulas of amortization, I should on grounds of obvious justice, adopt the method which involves the lesser deduction from capital made on the ground of an assumed but fictitious payment in the past. This case only strengthens the convictions I have previously arrived at, that the straight-line method is entirely unsuitable as a basis of valuation of properties of long life.*

In conclusion, the writer takes the liberty of calling to the attention of those interested in this subject a professional paper upon "Practical Checks upon Water Works Depreciation Estimates" recently submitted by him to and which will shortly appear in the *Proceedings* of the American Society of Civil Engineers. In it will be found certain historic records of water works depreciation and a more detailed discussion upon the practical aspects of this subject, together with the reason for the need of discrimination in the choice of depreciation determination methods, as an aid to sound judgment based upon experience, which must in the last analysis be the final arbiter.

John W. Hill: In this discussion of the Committee Report on Depreciation it will be understood that it applies to depreciation of water works and other public utility properties.

Depreciation, as at date of valuation, is the reduction in worth of any structure, machine or property, constituting part of a public utility, and the difficulty has been, and still continues, in arriving at the true reduced values of property subject to ordinary wear and tear, varying working conditions, natural improvement in the art and the destructive influence of time.

All structures and property, real estate excepted, come under this rule, and experience in building, operating, and examining water

works properties, furnishes the information upon which the estimate of the life of structures is based. But two or more engineers of equal experience and knowledge, may honestly differ on the useful life of physical details, and will accordingly hold different opinions on their depreciated values. It does not seem to the writer that fixed standards can ever be established for the life of the elements of a public utility, although something approaching this is necessary if "valuers" are to come to reasonable agreement in determining depreciation and present worth.

Taking as an example steam pumping engines and neglecting obsolescence in due time, there is an uncertain range of life to such machinery due to a combination of causes; a good engine on a poor foundation will probably have a shorter useful life and larger depreciation at the date of valuation than a poor engine on a good foundation, but supposing both the engine and foundation to be good then the management and daily care will have an influence to shorten or lengthen the useful life of the machine. The writer has seen this so often, in connection with water works pumping engines, that no fixed life can be assigned to apply universally to any kind of pumping machinery, and in such case, no matter by what method depreciation is figured, it is liable to be in error unless the valuer has had long experience with the particular type of pumping engine that he is dealing with in the valuation. A good prediction is the useful life under the conditions which he finds upon viewing the property. Some of the Simpson compound pumping engines in the East London Water Works have given satisfactory performance through more than fifty years. Other high class pumping engines, within the writer's experience, have become decidedly ram-shackle and not worth general repair in half that length of time.

The same may be said of steam boilers. The writer has known of shell boilers being in satisfactory service for over thirty-five years, but it is doubtful if anyone in determining the depreciation of boilers, would take this length of life as the probable useful life of boilers in service today.

Concerning the majority and minority reports of the Committee on Depreciation, there seems to be only a difference as to whether the "sinking fund theory" with interest compounded, or the "straight line theory," which assumes a uniform rate percentage depreciation for the assumed life of the property, shall apply to all of the property of the utility.

The sinking fund method is readily figured from the interest tables of the life insurance companies, and has frequently been used at a probable rate of interest (compounded) for the assumed life of the property.

The writer has used upon a number of occasions in valuing water works properties, the sinking fund theory for present worth or depreciation, which supposes that a certain sum set aside annually at the rate of interest probably adapted to the time the fund is to run, i.e., the life of the property under consideration, with interest compounded, will at the end of that life represent the original cost of the property. But the method has seemed to him at times to be more or less "academic," and liable to error on the wrong side by reason of the small annual increments to the sinking fund, and the chances of unexpected wear and tear, accidents and obsolescence to structures well within their supposed or real useful life.

The straight line theory, when compared with the sinking fund theory, will show a larger accumulation in the sinking fund or a larger depreciation of value of the property, at any given date of valuation short of the assumed life.

When engineers cannot agree, and the courts cannot agree, on a uniform method of figuring depreciation or present worth of public utilities property, it is evident that the subject is profound, and its solution by no means obvious or easy. The writer has acted as commissioner, auditor, appraiser, or witness in many appraisals of public utilities, either for purchase, fixing values of property for bond issues, or for rate making, and at no time has he felt that he so thoroughly understood the subject of depreciation as to be absolutely secure in his conclusion.

Depreciation, whether figured upon the sinking fund theory or upon the straight line theory, will depend for its accuracy upon the assumed useful life of the structure or property. If the life assumed be too long, the payments by either method of calculation will be too small, and if the life be figured too short, then the payments and depreciation as at the date of valuation will be too large, so that, entirely aside from the method of figuring depreciation, it is necessary, if this is to be reasonably exact, that a correct estimate of the useful life of structures or property should first be made and agreed upon if possible.

The accompanying table has been compiled from figure 1 of the majority report, and from calculations of depreciation by the straight

line method for a probable useful life ten to sixty years by ten year increments of time.

Percentage depreciation

S. F. = Sinking fund; interest rate 4 per cent compounded. S. L. = Straight line

AGE	USEFUL LIFE ASSUMED											
	10 years		20 years		30 years		40 years		50 years		60 years	
	S. F.	S. L.	S. F.	S. L.	S. F.	S. L.	S. F.	S. L.	S. F.	S. L.	S. F.	S. L.
years												
10	100	100	40	50	21	33	12	25	8	20	5	17
20			100	100	54	66	31	50	20	40	13	33
30					100	100	60	75	37	60	24	50
40							100	100	62	80	40	67
50									100	100	64	83
60											100	100

This shows that the larger percentage payments or amounts will be charged off for depreciation by the straight line theory. It is obvious from the comparative table that the payments or reductions of value of structures by the straight line theory will produce considerably more than 100 per cent of the cost price of the property or structure at the end of its assumed useful life, if the payments be invested and interest compounded.

It seems to the writer that this of itself should set aside the straight line theory, except as mentioned in both the majority and minority reports for short lived low cost structures or property, where the difference in the accumulated payments will not vary materially at any date of valuation short of the useful life.

In principle, if the straight line theory is wrong in the case of high cost long lived units, it is also wrong for low cost short lived units, although the difference in the depreciation as figured will be less apparent with the latter.

A general scheme of useful life for pumping machinery, boilers, water meters, stand pipes, reservoirs, distributing systems and appurtenances, etc., is a dangerous proposition, because it will not fit these various elements in all or in many instances, due to the many causes operating to lengthen or shorten the useful life of details.

If a theory of depreciation starts with the assumption that annual payments to a sinking fund invested at an assumed rate of interest compounded for the time the fund runs, shall recover the original cost and no more, then the life insurance or sinking fund theory is the only one that will produce this result. If, however, one starts on the theory that contingencies in the way of accidents, obsolescence, and non-continued use should be provided for, then this will require either an assumption of a life shorter than the probable useful life, or calculation of present worth by some other than the sinking fund theory.

The whole problem is exceedingly complicated and after reading every report, paper or discussion upon the subject which has been available for twenty-five years, and having served as an appraiser or expert for more than twenty valuation investigations, the writer still sees great difficulty in harmonizing the diverse views on the present worth of structures and properties entering into public and other utilities.

On long life costly property the straight line method of depreciation is not only unjust to the consumer, but is unjust to the owner of the property for the purpose of sale. If a price is desired for the transfer of a public utility to a municipal corporation, and depreciation was generally figured on the straight line basis, it would materially lower the price to the prejudice of the owner.

SOCIETY AFFAIRS

NEW YORK SECTION

The Section held a meeting at the McAlpin Hotel on October 16, 1918, at which the attendance was 47. The chairman of the Section, W. W. Brush, presided. An explanation of a leak which developed in one of the shafts of the Manhattan tunnel of the Catskill water supply system was given by J. Waldo Smith and the presiding officer, and a description of the method of checking the waste of water in Buffalo was given by E. D. Case. Models of various structures on the Catskill aqueduct were exhibited by the Board of Water Supply.

The Section held a meeting at the McAlpin Hotel on December 20, 1918, at which the attendance was 85. Papers on water meter practice were read by D. W. French and Wm. R. Edwards. The meeting adjourned at 3 o'clock and visits were then made to the plants of the Neptune Meter Company, Thomson Meter Company and National Meter Company.

ADDITIONS TO MEMBERSHIP

Active

Charles W. Graff, Superintendent of Filtration, York, Pennsylvania.

Ray K. Holland, Civil Engineer, Ann Arbor, Michigan.

Lawrence C. Hough, Civil Engineer, 25 Elm Street, New York City.

S. Willard Jacobs, San. Eng., 18 E. 41st St., New York.

J. D. Kinnett, Chairman Water Board, Macon, Georgia.

Taylor Kussmaul, Supt. Water & Light, Newark, Ohio.

Reeves J. Newsom, Water Commissioner, Lynn, Massachusetts.

Antonio Paitovi, Civil Engineer, Buenos Aires, Argentina.

Lewis A. Quigley, Superintendent Water Works, Lawrence, Kansas.

Clarence Eugene Ridley, City Engineer, Port Arthur, Texas.

Junichi Sawai, Engineer Water Department, Osaka, Japan.

A. J. Smalshaf, U. S. Public Health Service, Columbus, Georgia.

Joseph A. Vertefeuille, Assistant Engineer, Richmond Hill, New York.

Corporale, City Water & Lighting Dept., Lincoln, Neb.

Associate

Charles W. Larner, Widener Building, Philadelphia, Pennsylvania.

DEATHS

W. L. Cameron, Honorary Member; elected member, March 29, 1881; died November 13, 1918.

Capt. Granville R. Jones, elected Member, May 12, 1908; died December 22, 1918.

Major Bernard Matthew, elected Member Nov. 24, 1919; died June 15, 1918.

ADDITIONS TO ROLL OF HONOR

BAUEREISEN, R. J. Quartermaster Corps, Construction Division, East Alton, Illinois.

BROWER, IRVING C. Major Quartermaster Corps, Construction Division, Washington, D. C.

DONNELLEY, RICHARD, 1st Lieut. E. R. C.

* JONES, GRANVILLE R. ,Captain Sanitary Corps, Camp Bennin Columbia, Georgia.

McMANE, WM. I., First Lieutenant, Quartmaster Corps, Maintenance and Repair Branch, Washington, D. C.

PRUETT, G. C., Captain, Corps of Engineers, Fort Keough, Montana.

REES, S. P., First Lieutenant, Quartermaster Corps, Camp Jackson, Columbia, South Carolina.

ROBERTS, EARL I., Second Lieutenant, Sanitary Corps, A. E. F.

THORNELL, JOSEPH B., Med. Corps, Camp Gordon, Ga.

WAGNER, BERNARD MATTHEW, Major, U. S. R. C.

WILSON, EDGAR K., Captain 555th Engineers, Camp Humphreys, Virginia.

ADDITIONS TO JUNIOR ROLL OF HONOR

LEOPOLD, F. O. (son F. B. Leopold), Water Purification Section, Company F, 26th Engineers, A. E. F.

*Died in camp.